BULLETIN

OF THE

ILLINOIS STATE LABORATORY

OF

NATURAL HISTORY

URBANA, ILLINOIS, U. S. A.

VOL. VIII. FEBRUARY, 1909 ARTICLE III.

ON THE GENERAL AND INTERIOR DISTRIBUTION OF ILLINOIS FISHES

BY

STEPHEN A. FORBES, PH.D.

ERRATA AND ADDENDA.

Page 58, line 7, for *ovalis* read *ovata*.

Page 85, line 8, for *longicaudus* read *longicauda*, and just above *Phacus pleuronectes* read the following paragraph:—

Phacus longicauda var. *torta*, n. var.—This variety, for which I propose the name *torta* because of the twisted body, is figured by Stein ('78, Taf. 20, Fig. 3). It occurred sparingly in midsummer from July to September, rarely in October, in 1896 and 1897.

Page 91, line 18, after *T. caudata* Ehrb. read *T. lagenella* Stein.

Pages 153, line 3 from bottom, 168, line 16, and 178, line 14, for '*98* read '*98a*.

Pages 156, line 11, 159, line 16, and 161, line 5 from bottom, for '*93* read '*98a*.

Pages 175, line 5, 186, line 3, and 208, line 17, for *Bimærium* read *Dimærium*.

Page 288, line, 3 for *Lampsilus* read *Lampsilis*.

Page 292, line 13, for *gracilis* read *gracile*.

Page 471, line 3 under heading beetles, for *pennsylvanicus* read *pennsylvanica*

ARTICLE III.—*On the General and Interior Distribution of Illinois Fishes.** BY S. A. FORBES.

The geography of Illinois is, in its most obvious features, so simple and so monotonous that one naturally expects a similar simplicity and monotony in the geographic distribution of its plants and animals. The plan of its hydrography is as little complicated as the geography of its land areas. Surrounded on more than two thirds of its circumference by three large rivers, the Mississippi, the Ohio, and the Wabash, with Lake Michigan covering a narrow strip at its northeast corner and draining a bordering region of scarcely greater area, its other waters flow southwestward into the Mississippi and southward into the Wabash and the Ohio, all mingling finally opposite its southernmost extremity for their journey to the Gulf. Its principal watersheds are inconspicuous ridges or slightly elevated plains, most of them originally more or less marshy, and the headwaters and tributaries of its various stream systems so approach and intermingle that in times of flood they formed an interlacing network, through which it would seem that a wandering fish might have found its way in almost any direction and to almost any place.

Its climate varies considerably, of course, within the five and a half degrees of its length from north to south, but by insensible gradations, with no lines of abrupt transition anywhere to set definite boundaries to the range of its aquatic species.

Its surface geology is more diversified than its topography, and its soils, although uniformly fertile throughout most of the state, differ notably in their origin and physical constitution, some of these differences being such as to affect more or less the surface waters and, through them, to influence the conditions of aquatic life. The extreme northwestern and the extreme southern parts of the state are bare of drift, and their soil is derived immediately from the underlying rock; but the surface of all the remainder of the state, excepting a

*This article is a reprint, with minor changes, of a chapter in the introduction to "The Fishes of Illinois," by S. A. Forbes and R. E. Richardson.

small area above the mouth of the Illinois, has been repeatedly worked over by ice in the course of the successive divisions of the glacial period. The oldest glaciated area, known as the lower Illinoisan glaciation, covers the greater part of southern Illinois and a narrow belt of the southeast part of the central section of the state. Next to this at the northwest, and immediately east of the lower half of the Illinois River, is the middle Illinoisan; above this, in the west-central part of the state, between the Illinois River and the Rock, is the upper Illinoisan; and still farther north, in the Rock River basin, are the Iowan and Preiowan glaciations, reaching northward across the Wisconsin boundary. East of the last three mentioned, and north of the southern Illinois district, the Wisconsin glaciation, the most recent of the series, covers about a fourth of the state. It is to the peculiar features of the lower Illinoisan glaciation especially that we shall presently be compelled to pay particular attention, because of their evident effect on the distribution of a considerable group of our fishes.

The topographical relations of the state to the surrounding territory are as simple and open as its own interior hydrography, and there is little to suggest the possibility of anything in the least peculiar in the general constitution or the relations of its fauna, or anything problematical or especially interesting in the details of the distribution of its native fishes. We shall find reason to believe, however, that this appearance is misleading, and that the subject, studied in detail, contains matter of unusual interest, and presents problems of considerable difficulty, a solution of which will lead us to some novel results.

It is true, however, generally speaking, that the distribution of Illinois fishes reflects, in uniformity and relative monotony, the features of the topography of the state. A few species occurring in Lake Michigan and characteristic of the Great Lakes are, in fact, the only Illinois fishes which are definitely and permanently separated from their fellows in other Illinois waters by what may be called geographical conditions, and these conditions are not physical obstacles to their passage from Lake Michigan to the Illinois River.

Excluding, for the moment, these fishes special to the Great Lakes, we find elsewhere in Illinois a general commingling and overlapping of the fish population of the surrounding territory, the limits

to whose range are climatic, local, and ecological, but topographic only in a secondary sense.

THE GENERAL DISTRIBUTION

Most of the 150 species of the native fishes of Illinois range far and wide in all directions beyond its narrow boundaries, thus illustrating the breadth and the simplicity of our geographical affiliations with the surrounding territory; but a considerable number, on the other hand, coming into Illinois from one direction, do not pass beyond it in another, some part of the boundary of the general area of their distribution passing through our state. Several southern fishes go no farther north than Illinois; some northern fishes go no farther south; some eastern species find here their western limit; and a few western species range no farther east. The comparison of these geographical groups whose areas overlap by their borders here in Illinois is a matter of special interest to the student of distribution, because it is in them that we find indicated the more remote affinities of our fish fauna, and from them, if anywhere, we may glean suggestions of its various origins.

It will be convenient for a discussion of this subject to divide the general expanse over which Illinois fishes are distributed, into the following twelve districts: 1, the upper Mississippi Valley, including the Missouri and its tributaries; 2, the lower Mississippi Valley, including the Ohio and its tributaries; 3, the far North, extending northward from the headwaters of the Mississippi, east to the Lake Superior drainage, and west to the Rocky Mountains; 4, the far Northwest, separated from the preceding by the Rocky Mountains range; 5, the Great Lake region; 6, the district of Quebec and New England; 7, the Hudson River district; 8, the north Atlantic drainage, from New England to the Chesapeake Bay; 9, the south Atlantic, from the Chesapeake Bay to Florida; 10, the peninsula of Florida; 11, the east Gulf district, bounded by the Mississippi drainage on the west; and 12, the west Gulf district, bounded by the Mississippi drainage on the east, and extending west and south to include the Rio Grande and its tributaries. The following table shows the recorded distribution of our species over the territory so divided.

TABLE OF THE GENERAL DISTRIBUTION OF ILLINOIS FISHES

	Great Lake Basin	Quebec and New England	Hudson River	North Atlantic	South Atlantic	Florida Peninsula	East Gulf	Lower Miss. and Ohio	Upper Miss. and Mo.	West Gulf and Rio Grande	Far Northwest	Far North
Silvery lamprey (*Ichthyomyzon*)	+	+	...	...	...	...	...	+	+	...	...	...
Brook lamprey (*Lampetra*)	+	...	...	...	...	...	...	+	+	...	...	...
Paddle-fish (*Polyodon*)	+	...	...	...	...	...	...	+	+	...	...	...
Lake sturgeon (*Acipenser*)	+	+	...	...	...	...	...	+	+	...	...	+
Shovel-nosed sturgeon	...	...	...	...	...	...	...	+	+	+	...	...
White sturgeon (*P. albus*)	...	...	...	...	...	...	...	+	...	...	...	...
Long-nosed gar	+	+	...	+	+	+	+	+	+	+	...	...
Short-nosed gar	+	...	...	...	...	+	+	+	+	...	...	...
Alligator-gar	...	...	...	...	...	+	...	+	+	+	...	...
Dogfish (*Amia*)	+	+	...	...	+	+	+	+	+	...	...	...
Mooneye (*alosoides*)	...	...	...	...	...	...	...	+	+	...	...	+
Toothed herring (*tergisus*)	+	+	...	...	...	...	...	+	+	...	...	+
Gizzard-shad (*Dorosoma*)	+	...	...	+	+	+	+	+	+	+	...	...
Skipjack (*chrysochloris*)	+	...	...	...	...	..	+	+	+	+	...	...
Whitefish	+	+	...	...	...	...	...	...	...	...	...	+
Lake herring	+	+	...	...	...	...	...	...	...	...	...	...
Lake trout	+	+	...	...	...	...	...	...	...	...	+	+
Eel	+	+	+	+	+	+	+	+	+	+	...	...
Black-horse (*Cycleptus*)	...	...	...	...	...	...	...	+	+	+	...	...
Red-mouth buffalo (*cyprinella*)	...	...	...	...	...	...	...	+	+	...	...	+
Mongrel buffalo (*urus*)	...	...	...	...	...	...	...	+	+	...	...	...
Small-mouth buffalo (*bubalus*)	...	...	...	...	...	...	...	+	+	...	...	...

TABLE OF THE GENERAL DISTRIBUTION OF ILLINOIS FISHES—*continued*

	Great Lake Basin	Quebec and New England	Hudson River	North Atlantic	South Atlantic	Florida Peninsula	East Gulf	Lower Miss. and Ohio	Upper Miss. and Mo.	West Gulf and Rio Grande	Far Northwest	Far North
River carp (*carpio*)								+	+	+		
Blunt-nosed carp (*difformis*)								+	+			
Lake carp (*thompsoni*)	+	+							+			
Quillback carp (*velifer*)	+							+	+	+		+
Chub-sucker	+	+	+	+	+	+	+	+	+	+		
Striped sucker	+			+	+		+	+	+	+		
Common sucker (*commersonii*)	+	+	+	+	+			+	+			+
Hogsucker (*nigricans*)	+	+		+	+		+	+	+			
White-nosed sucker (*anisurum*)	+	+			+			+	+			+
Common red-horse (*aureolum*)	+	+	+					+	+			+
Short-headed red-horse (*breviceps*)	+							+	+			
Placopharynx duquesnei	+						+	+	+			
Harelipped sucker (*Lagochila*)	+							+	+			
Stone-roller (*Campostoma*)	+				+		+	+	+	+		
Red-bellied dace (*Chrosomus*)	+	+		+	+			+	+			
Silvery minnow (*H. nuchalis*)				+	+		+	+	+	+		+
Hybognathus nubila								+	+			
Black-head minnow (*P. promelas*)	+	+						+	+	+		+
Blunt-nosed minnow (*P. notatus*)	+	+		+			+	+	+			
Horned dace (*Semotilus*)	+	+	+	+	+		+	+	+			
Opsopœodus emiliæ	+				+		+	+	+			
Golden shiner (*Abramis*)	+	+	+	+	+	+	+	+	+	+		

TABLE OF THE GENERAL DISTRIBUTION OF ILLINOIS FISHES—*continued*

	Great Lake Basin	Quebec and New England	Hudson River	North Atlantic	South Atlantic	Florida Peninsula	East Gulf	Lower Miss. and Ohio	Upper Miss. and Mo.	West Gulf and Rio Grande	Far Northwest	Far North
Bullhead minnow (*Cliola vigilax*)	+						+	+	+	+		
Notropis anogenus	+								+			
N. cayuga	+							+	+			+
N. cayuga atrocaudalis	+	+						+		+		
N. heterodon	+							+	+			
Straw-colored minnow (*N. blennius*)	+	+						+	+	+		+
N. phenacobius									+			
N. gilberti									+			
N. illecebrosus	+							+	+			
Redfin (*N. lutrensis*)								+	+	+		
Spot-tailed minnow (*N. hudsonius*)	+	+	+	+	+			+	+			
Silverfin (*N. whipplii*)	+	+						+	+			
Common shiner (*N. cornutus*)	+	+	+	+	+		+	+	+			+
Notropis pilsbryi								+	+			
N. jejunus								+	+			+
Shiner (*N. atherinoides*)	+	+						+	+			+
Notropis rubrifrons	+	+			+			+	+			
Blackfin (*N. umbratilis atripes*)	+				+		+	+	+			
Ericymba buccata	+						+	+	+			
Sucker-mouthed minnow (*Phenacobius*)								+	+	+		
Long-nosed dace (*R. cataractæ*)	+	+		+	+			+	+	+	+	+

TABLE OF THE GENERAL DISTRIBUTION OF ILLINOIS FISHES—*continued*

	Great Lake Basin	Quebec and New England	Hudson River	North Atlantic	South Atlantic	Florida Peninsula	East Gulf	Lower Miss. and Ohio	Upper Miss. and Mo.	West Gulf and Rio Grande	Far Northwest	Far North
Black-nosed dace (*R. atronasus*)	+	+	+	+	+			+	+			
Hybopsis hyostomus							+	+	+			
Spotted shiner (*H. dissimilis*)	+							+	+			
Silver chub (*amblops*)	+						+	+	+			
Storer's chub	+							+	+			+
River chub (*kentuckiensis*)	+			+	+		+	+	+			
Flat-headed chub (*Platygobio*)								+	+			+
Blue cat (*furcatus*)								+	+	+		
Ictalurus anguilla								+		+		
Channel-cat (*punctatus*)	+					+	+	+	+	+		+
Great Lake catfish (*lacustris*)	+	+										
Yellow bullhead (*natalis*)	+				+	+	+	+	+	+		
Common bullhead (*nebulosus*)	+	+	+	+	+	+	+	+	+	+		+
Black bullhead (*melas*)	+						+	+	+			
Mud-cat (*Leptops*)							+	+	+	+		
Common stonecat (*N. flavus*)	+			+				+	+			
Tadpole cat (*S. gyrinus*)	+		+	+		+	+	+	+			
Freckled stonecat (*S. nocturnus*)								+	+	+		
Slender stonecat (*S. exilis*)	+							+	+			
Brindled stonecat (*S. miurus*)	+							+	+			
Mud-minnow	+	+		+				+	+			
Grass pike (*Esox vermiculatus*)	+						+	+	+			

TABLE OF THE GENERAL DISTRIBUTION OF ILLINOIS FISHES—*continued*

	Great Lake Basin	Quebec and New England	Hudson River	North Atlantic	South Atlantic	Florida Peninsula	East Gulf	Lower Miss. and Ohio	Upper Miss. and Mo.	West Gulf and Rio Grande	Far Northwest	Far North
Pike (*E. lucius*)	+	+	...	+	...	...	...	+	+	...	+	+
Muskallunge	+	+	...	...	...	...	...	+	+	...	...	+
Menona top-minnow (*F. diaphanus m.*)	+	...	...	...	...	...	...	+	+	...	...	...
Striped top-minnow (*F. dispar*)	+	...	...	...	...	...	+	+	+	...	...	...
Common top-minnow (*F. notatus*)	+	...	...	...	...	...	+	+	+	+	...	..
Viviparous top-minnow (*affinis*)	...	...	...	+	+	+	+	+	+	+	...	...
Chologaster papilliferus	...	...	...	...	...	...	...	...	+	...	...	..
Brook stickleback	+	+	...	...	...	...	...	+	+	...	...	+
Nine-spined stickleback	+	+	+	...	...	...	...	...	...	...	+	+
Trout-perch	+	+	...	+	...	...	...	+	+	...	...	+
Brook silverside	+	...	...	...	+	+	+	+	+	...	...	...
Pirate-perch	+	...	...	+	+	+	+	+	+	...	...	...
Pigmy sunfish (*Elassoma*)	...	...	...	...	+	...	+	+	...	...	...	...
White crappie (*annularis*)	+	...	...	+	+	...	+	+	+	...	...	...
Black crappie (*sparoides*)	+	+	...	+	+	+	+	+	+	...	...	...
Round sunfish	...	...	...	...	+	+	+	+	...	...	...	...
Rock bass	+	+	+	+	+	...	+	+	+	...	...	+
Warmouth (*Chænobryttus*)	+	...	...	...	+	+	+	+	+	+	...	...
Green sunfish (*cyanellus*)	+	...	...	...	...	...	...	+	+	+	...	...
Lepomis ischyrus	...	...	...	...	...	...	...	...	+	...	...	...
L. symmetricus	...	...	...	...	...	...	...	+	...	+	...	...
L. euryorus	+	...	...	...	...	...	...	...	+	...	...	...

TABLE OF THE GENERAL DISTRIBUTION OF ILLINOIS FISHES—*continued*

	Great Lake Basin	Quebec and New England	Hudson River	North Atlantic	South Atlantic	Florida Peninsula	East Gulf	Lower Miss. and Ohio	Upper Miss. and Mo.	West Gulf and Rio Grande	Far Northwest	Far North
Lepomis miniatus						+	+	+	+			
Long-eared sunfish	+				+	+	+	+	+	+		
Orange-spotted sunfish (*humilis*)								+	+	+		
Bluegill (*pallidus*)	+				+	+	+	+	+	+		
Eupomotis heros							+	+		+		
Pumpkinseed (*gibbosus*)	+	+	+	+	+			+	+			
Small-mouthed black bass	+	+	+	+	+		+	+	+	+		
Large-mouthed black bass	+	+	+	+	+	+	+	+	+	+		+
Pike-perch (*S. vitreum*)	+	+		+	+		+	+	+			+
Sauger (*S. canadense griseum*)	+	+							+			+
Yellow perch	+	+	+	+	+			+	+			+
Log-perch (*P. caprodes*)	+	+		+			+	+	+	+		
Hadropterus evermanni								+	+			
H. phoxocephalus	+							+	+			
Black-sided darter (*H. aspro*)	+				+			+	+			+
Hadropterus ouachitæ								+				
H. evides	+							+	+			
H. scierus								+		+		
Cottogaster shumardi	+							+	+			
Green-sided darter (*blennioides*)	+						+	+	+			
Johnny darter (*B. nigrum*)	+	+	+	+	+			+	+			+
Boleosoma camurum							+	+	+	+		

TABLE OF THE GENERAL DISTRIBUTION OF ILLINOIS FISHES—*concluded*

	Great Lake Basin	Quebec and New England	Hudson River	North Atlantic	South Atlantic	Florida Peninsula	East Gulf	Lower Miss. and Ohio	Upper Miss. and Mo.	West Gulf and Rio Grande	Far Northwest	Far North
Crystallaria asprella	+							+				
Sand darter (*Ammocrypta*)	+							+	+	+		
Banded darter (*E. zonale*)	+						+	+	+			
Blue-breasted darter (*E. camurum*)	+							+	+			
Etheostoma iowæ									+			+
E. jessiæ	+						+	+	+	+		
Rainbow darter (*E. cæruleum*)	+			+				+	+	+		
Etheostoma obeyense								+				
E. squamiceps							+	+				
Fan-tailed darter (*E. flabellare*)	+	+		+	+			+	+			
Boleichthys fusiformis	+	+		+	+	+		+	+	+		
Least darter (*Microperca*)	+			+				+	+			
White bass (*Roccus chrysops*)	+	+						+	+			
Yellow bass (*Morone*)								+	+			
Sheepshead (*Aplodinotus*)	+	+					+	+	+	+		+
Miller's thumb	+	+		+	+		+	+	+			
Cottus ricei	+											
Uranidea kumlienii	+											
Burbot (*Lota*)	+	+	+					+	+			+
Number of species	108	53	19	40	45	23	56	134	131	47	4	37

Arranged according to the number of Illinois species in each, these districts succeed each other in the following order.

Districts	No. of species	Per cent. of all Illinois species
Lower Mississippi and Ohio valleys	134	89
Upper Mississippi and Missouri valleys	131	87
The Great Lake basin	108	72
The east Gulf district	56	37
Quebec and New England	53	36
The west Gulf and Rio Grande district	47	31
The south Atlantic district	45	30
The north Atlantic district	40	27
The far North	37	25
The Florida peninsula	23	15
The Hudson drainage	19	13
The far Northwest	4	3

Next to the two Mississippi Valley districts and the Great Lake basin, which average 124 Illinois species, our fishes are most largely represented in the east Gulf and the Quebec and New England districts, averaging 54 Illinois species—the first closely related to the lower Mississippi, and the second a continuation eastward of the Great Lake basin. Then follow the north and south Atlantic and the west Gulf districts, with an average of 43 species; the far North, the Florida peninsula, and the Hudson River districts, with 37 to 19 species; and, finally, the far Northwest, with but 4 Illinois species.

The northern and the southern affiliations of the assemblage of fishes represented in our Illinois collections may be contrasted by comparing the list of Illinois species occurring in either or both of the more northerly divisions—that is, the far North and the Quebec and New England districts—on the one hand, with a list of those found in either or all of the three most southerly districts—that is, the Florida peninsula, the east Gulf, and the west Gulf and Rio Grande—on the other hand. In this northern list of Illinois fishes there are 64 species, and in the southern list there are 77; but 25 of these species are more or less common to both north and south, leaving 39 Illinois fishes distinctively northern in their distribution and 52 distinctively southern. Northern and southern species thus mingle in our territory in unequal proportions, the southern element largely preponderating.

If we look to the further distribution of the northern and southern elements of our fish population, distinguishing northeastern from northwestern species, and southeastern from southwestern, we find that the southeastern species largely outnumber the southwestern in Illinois, and that the northeastern outnumber the northwestern. Thus there are 47 species of the west Gulf and Rio Grande region in this state, and 58 species of the east Gulf and Florida districts.

Further, there are more species known as common to Illinois and the far northeast than there are to Illinois and the southwestern district of the west Gulf and the Rio Grande. Notwithstanding the much greater distance from us of the Quebec and New England district, there are 53 of the fishes of that region known in Illinois to 47 of those of the west Gulf district. The northeastern fishes have, however, been much more carefully collected than the southwestern, and an equal knowledge of both districts might change these relative numbers.

THE INTERIOR DISTRIBUTION

The interior distribution of the fishes of the state may best be exhibited by treating each considerable stream-system as a unit, and comparing the fishes of each such system with all the others. The state may be conveniently divided into ten such hydrographic districts, as follows:

1. The Galena district, including the streams of the northwestern unglaciated area, most of which empty into the Mississippi through Galena, Apple, and Plum rivers. 2. The Rock River district, extending southward and westward from the northern boundary of the state to the Mississippi at the mouth of the Rock. 3. The Illinois district, including the entire drainage of the Illinois River. 4. The Michigan district, a narrow strip along the borders of Lake Michigan—the Lake Michigan drainage—most of which centers in the Chicago and the Calumet rivers. 5. The Mississippi River, and an irregular strip adjacent not included in any of the more definite river systems and mainly drained by small streams of the bluffs and neighboring highlands. This district is divided by the lower end of the Illinois basin. 6. The Kaskaskia basin. 7. The Illinois drainage of the Wabash, including that stream itself so far as it helps to form the boundary line between Illinois and Indiana. 8. The basin of the Big Muddy River, in the southwestern part of the state.

9. The Saline River basin, in the southeastern part of the state. 10. The Cairo district, the driftless area of extreme southern Illinois, drained by the Cache River and smaller tributaries of the Ohio. The Ohio itself is included in this last district.

The following list and table gives the details of the distribution of the species in a way to show the number of collections of each species made by us from each district. A cross opposite a species name indicates that the species occurs in the basin mentioned at the head of the column, but that it is not represented by preserved collections affording numerical data.

INTERIOR DISTRIBUTION OF ILLINOIS FISHES BY RIVER SYSTEMS
SPECIES AND NUMBER OF COLLECTIONS OF EACH

	Districts										Sections		
	Galena District	Rock River	Illinois River	Michigan Drainage	Mississippi and Creeks	Kaskaskia	Wabash	Big Muddy	Saline	Cairo District	North	Central	South
Number of species	44	92	128	57	97	69	95	42	55	101	120	123	119
Collections made	13	73	1115	20	57	41	103	10	18	95	269	1083	192
Silvery lamprey		1	12	1	+		1				+	+	+
Brook lamprey				1						1	+	0	+
Paddle-fish			8		+		+			1	0	+	+
Lake sturgeon			+	+	+					+	+	+	+
Shovel-nosed sturgeon			+		+		+			+	0	+	+
White sturgeon					4						0	+	0
Long-nosed gar		1	20	1	10	1	+			4	+	+	+

INTERIOR DISTRIBUTION OF ILLINOIS FISHES BY RIVER SYSTEMS
SPECIES AND NUMBER OF COLLECTIONS OF EACH—*continued*

	Districts										Sections		
	Galena District	Rock River	Illinois River	Michigan Drainage	Mississippi and Creeks	Kaskaskia	Wabash	Big Muddy	Saline	Cairo District	North	Central	South
Short-nosed gar	...	1	52	...	4	+	+	...	...	1	+	+	+
Alligator-gar	...	....	+	...	+	....	....	....	...	+	0	+	+
Dogfish	...	....	27	1	3	+	1	...	2	1	+	+	+
Mooneye	...	....	1	...	+	....	....	....	...	+	0	+	+
Toothed herring	...	....	8	1	+	....	....	....	...	7	+	+	+
Gizzard-shad	1	3	89	1	1	7	2	...	...	3	+	+	+
Skipjack	2	1	3	...	2	....	....	....	...	+	+	+	+
Whitefish	...	....	....	+	....	....	....	....	...	....	+	0	0
Lake herring	...	....	....	+	....	....	....	....	...	....	+	0	0
Lake trout	...	....	....	+	....	....	....	....	...	....	+	0	0
Eel	...	....	+	+	+	....	+	...	...	+	+	+	+
Black-horse	...	....	1	...	2	....	....	....	...	....	0	+	+
Red-mouth buffalo	1	1	28	...	9	....	2	...	...	1	+	+	+
Mongrel buffalo	1	....	17	1	1	....	....	....	...	....	+	+	+
Small-mouth buffalo	1	1	46	1	9	....	2	...	...	+	+	+	+
River carp	...	1	11	...	2	1	+	...	1	+	+	+	+
Blunt-nosed carp	1	6	54	...	8	15	21	...	3	3	+	+	+
Lake carp	...	....	10	...	1	....	....	....	...	....	+	+	0
Quillback carp	1	19	39	...	1	1	8	...	1	+	+	+	+

INTERIOR DISTRIBUTION OF ILLINOIS FISHES BY RIVER SYSTEMS
SPECIES AND NUMBER OF COLLECTIONS OF EACH—*continued*

	Districts										Sections		
	Galena District	Rock River	Illinois River	Michigan Drainage	Mississippi and Creeks	Kaskaskia	Wabash	Big Muddy	Saline	Cairo District	North	Central	South
Chub-sucker	...	4	48	...	2	21	47	6	7	10	+	+	+
Striped sucker	1	1	13	1	....	13	16	1	1	3	+	+	+
Common sucker	1	14	69	...	9	5	26	...	3	9	+	+	+
Long-nosed sucker	...	....	....	+	....	....	....	...	...	....	+	0	0
Hogsucker	1	11	61	...	1	9	27	...	...	1	+	+	+
White-nosed sucker	...	2	14	+	1	....	....	...	...	....	+	+	+
Common red-horse	2	13	90	...	5	10	25	...	1	2	+	+	+
Short-headed red-horse	...	4	39	1	3	7	2	...	...	+	+	+	+
Placopharynx duquesnei	...	1	1	...	+	....	1	...	...	+	+	+	+
Harelipped sucker	...	...	...	...	...	....	+	...	...	....	0	0	+
Stone-roller	1	20	99	...	14	9	36	1	1	10	+	+	+
Red-bellied dace	...	4	13	...	2	....	....	...	...	4	+	+	+
Silvery minnow	2	6	86	1	16	10	27	6	11	18	+	+	+
Hybognathus nubila	1	3	....	...	1	....	....	...	...	1	+	+	+
Black-head minnow	...	8	67	...	12	6	5	...	...	+	+	+	+
Blunt-nosed minnow	3	33	162	3	19	31	77	8	13	25	+	+	+
Horned dace	1	9	72	...	16	10	24	4	6	14	+	+	+
Opsopœodus emiliæ	...	3	49	1	1	1	18	3	6	4	+	+	+

INTERIOR DISTRIBUTION OF ILLINOIS FISHES BY RIVER SYSTEMS
SPECIES AND NUMBER OF COLLECTIONS OF EACH—*continued*

	Districts										Sections		
	Galena District	Rock River	Illinois River	Michigan Drainage	Mississippi and Creeks	Kaskaskia	Wabash	Big Muddy	Saline	Cairo District	North	Central	South
Golden shiner	1	18	183	1	8	19	50	7	10	10	+	+	+
Bullhead minnow	1	14	110	...	5	22	38	1	3	2	+	+	+
Notropis anogenus	....	....	2	....	....	....	....	....	....	....	+	0	0
Notropis cayuga	1	4	29	2	5	....	1	....	....	1	+	+	0
N. heterodon	....	5	81	1	1	....	4	....	....	3	+	+	+
Straw-colored minnow	1	22	108	4	9	6	44	...	2	1	+	+	+
Notropis phenacobius	....	....	2	....	....	....	....	....	....	....	+	0	0
N. gilberti	....	3	15	...	10	....	2	....	....	....	+	+	+
N. illecebrosus	....	....	2	...	1	....	17	....	....	+	+	+	+
Spot-tailed minnow	....	4	133	4	4	....	....	....	....	2	+	+	+
Redfin	....	1	142	9	16	4	....	4	1	10	+	+	+
Silverfin	3	34	116	1	8	29	71	2	3	6	+	+	+
Common shiner	1	19	105	...	11	14	22	...	1	12	+	+	+
Notropis pilsbryi	....	....	1	....	....	....	....	....	....	....	+	0	0
N. jejunus	1	5	21	1	10	....	5	...	2	5	+	+	+
Shiner	3	8	82	6	8	4	19	4	6	11	+	+	+
Notropis rubrifrons	2	4	8	....	....	....	....	....	....	....	+	+	0
Blackfin	2	9	67	...	3	25	56	5	11	19	+	+	+
Ericymba buccata	....	....	4	....	....	25	58	....	....	+	0	+	+

INTERIOR DISTRIBUTION OF ILLINOIS FISHES BY RIVER SYSTEMS
SPECIES AND NUMBER OF COLLECTIONS OF EACH—*continued*

	Districts										Sections		
	Galena District	Rock River	Illinois River	Michigan Drainage	Mississippi and Creeks	Kaskaskia	Wabash	Big Muddy	Saline	Cairo District	North	Central	South
Sucker-mouthed minnow	2	15	78	...	13	17	36	1	4	8	+	+	+
Long-nosed dace	...	...	...	...	...	...	...	...	...	1	0	0	+
Black-nosed-dace	...	1	4	...	...	...	...	...	...	1	+	0	+
Hybopsis hyostomus	...	2	1	...	...	...	...	...	...	...	+	+	0
Spotted shiner	...	6	3	...	...	1	1	...	...	...	+	+	+
Silver chub	...	...	2	...	...	10	37	4	2	...	0	+	+
Storer's chub	...	1	7	...	7	...	5	...	4	4	+	+	+
River chub	1	12	90	...	8	10	16	...	...	1	+	+	+
Flat-headed chub	...	...	...	...	...	...	...	...	...	3	0	0	+
Blue cat	...	...	1	...	1	...	...	...	...	2	0	+	+
Ictalurus anguilla	...	...	+	...	+	...	...	...	...	+	0	+	+
Channel-cat	...	17	108	...	7	17	26	2	1	2	+	+	+
Great Lake catfish	...	...	...	+	...	...	...	...	...	...	+	0	0
Yellow bullhead	...	3	82	...	...	10	18	3	4	6	+	+	+
Common bullhead	...	...	42	...	1	1	...	...	...	4	+	+	+
Black bullhead	1	11	144	...	19	15	35	4	6	10	+	+	+
Mud-cat	+	3	22	...	2	1	2	...	...	+	+	+	+
Stonecat	2	3	32	...	1	1	2	...	...	+	+	+	0
Tadpole cat	...	2	132	...	11	14	21	3	8	5	+	+	+

INTERIOR DISTRIBUTION OF ILLINOIS FISHES BY RIVER SYSTEMS
SPECIES AND NUMBER OF COLLECTIONS OF EACH—*continued*

	Districts										Sections		
	Galena District	Rock River	Illinois River	Michigan Drainage	Mississippi and Creeks	Kaskaskia	Wabash	Big Muddy	Saline	Cairo District	North	Central	South
Freckled stonecat	...	....	5	...	1	2	+	...	...	....	0	+	+
Slender stonecat	1	....	1	...	2	....	....	...	...	2	+	+	+
Brindled stonecat	...	....	1	...	....	1	26	...	5	1	0	+	+
Mud-minnow	...	8	18	1	1	....	4	1	1	6	+	+	+
Grass pike	...	5	61	1	4	11	19	7	6	9	+	+	+
Pike	...	2	17	1	1	....	....	...	...	1	+	+	0
Muskallunge	...	....	+	...	....	....	....	...	...	....	+	0	0
Menona top-minnow	...	....	11	7	....	....	+	...	...	....	+	+	0
Striped top-minnow	...	1	75	1	....	....	8	...	...	5	+	+	+
Common top-minnow	1	6	66	...	6	23	58	8	17	27	+	+	+
Viviparous top-minnow	...	....	1	...	1	....	4	1	2	9	0	+	+
Chologaster papilliferus	...	....	....	...	....	....	....	...	...	6	0	0	+
Brook stickleback	...	....	1	2	....	....	....	...	...	....	+	0	0
Nine-spined stickleback	...	....	....	1	....	....	....	...	...	....	+	0	0
Trout-perch	...	....	14	1	....	....	....	...	...	....	+	+	0
Brook silverside	1	6	89	2	2	1	21	...	...	....	+	+	+
Pirate-perch	...	....	54	...	....	9	11	7	11	9	+	+	+
Pigmy sunfish	...	....	....	...	....	....	5	...	...	1	0	0	+

INTERIOR DISTRIBUTION OF ILLINOIS FISHES BY RIVER SYSTEMS
SPECIES AND NUMBER OF COLLECTIONS OF EACH—*continued*

	Districts										Sections		
	Galena District	Rock River	Illinois River	Michigan Drainage	Mississippi and Creeks	Kaskaskia	Wabash	Big Muddy	Saline	Cairo District	North	Central	South
White crappie	2	9	119	2	13	6	14	3	3	6	+	+	+
Black crappie		8	130	3	15	8	13	3	1	....	+	+	+
Round sunfish			1	...	....	....	1	1	2	8	0	0	+
Rock bass		4	35	1	3	2	1	1	...	2	+	+	+
Warmouth		3	83	...	3	5	10	6	6	11	+	+	+
Green sunfish	2	20	158	...	16	33	57	7	12	15	+	+	+
Lepomis ischyrus		1	3	...	....	....	....	....	....	....	+	+	0
L. symmetricus		....	2	...	....	....	3	....	....	4	0	+	+
L. euryorus		....	1	...	....	....	....	....	....	....	0	+	0
L. miniatus		....	24	...	1	....	2	....	....	....	+	+	+
Long-eared sunfish		3	37	1	....	27	57	7	8	16	+	+	+
Orange-spotted sunfish		5	112	...	22	15	23	2	3	3	+	+	+
Bluegill	2	7	179	1	6	3	18	1	1	6	+	+	+
Eupomotis heros		....	....	....	....	....	5	....	....	1	0	0	+
Pumpkinseed		4	82	4	2	....	1	....	....	1	+	+	+
Small-mouthed black bass		16	69	...	5	2	8	1	...	3	+	+	+
Large-mouthed black bass		7	135	4	13	8	33	2	4	12	+	+	+
Pike-perch		3	20	1	13	1	+	....	....	....	+	+	+

INTERIOR DISTRIBUTION OF ILLINOIS FISHES BY RIVER SYSTEMS
SPECIES AND NUMBER OF COLLECTIONS OF EACH—*concluded*

	Districts										Sections		
	Galena District	Rock River	Illinois River	Michigan Drainage	Mississippi and Creeks	Kaskaskia	Wabash	Big Muddy	Saline	Cairo District	North	Central	South
Sauger		1	13		3	1					+	+	0
Yellow perch		+	75	3	6						+	+	0
Log-perch		4	35	3	5	9	8		1	2	+	+	+
Hadropterus evermanni			3								0	+	0
H. phoxocephalus		12	58		3	10	6		2		+	+	+
Black-sided darter	2	15	70		1	22	42	2	7	11	+	+	+
Hadropterus ouachitæ							1				0	0	+
H. evides		1									+	0	0
H. scierus			1				1				0	+	0
Cottogaster shumardi			14			2	1				0	+	+
Green-sided darter			+				36				0	+	+
Johnny darter	3	22	100	3	10	27	58	1	6	8	+	+	+
Boleosoma camurum		1	45	2	2	12	17	7	11	10	+	+	+
Crystallaria asprella	1	3			2		1				+	+	+
Sand darter		3	7		1	2	16				+	+	+
Banded darter	1	11	21				1				+	+	+
Blue-breasted darter		2	6	1						1	0	+	0
Etheostoma iowæ		2	4	1						1	+	0	+
E. jessiæ		4	119		5	11	14	2	1	4	+	+	+

INTERIOR DISTRIBUTION OF ILLINOIS FISHES BY RIVER SYSTEMS
SPECIES AND NUMBER OF COLLECTIONS OF EACH—*concluded*

	Districts										Sections		
	Galena District	Rock River	Illinois River	Michigan Drainage	Mississippi and Creeks	Kaskaskia	Wabash	Big Muddy	Saline	Cairo District	North	Central	South
Rainbow darter	2	9	39	...	1	2	29	1	4	13	+	+	+
Etheostoma obeyense	...	....	.....	...	....	....	....	...	1	....	0	0	+
E. squamiceps	...	....	....	...	....	1	1	...	1	7	0	+	+
Fan-tailed darter	1	6	11	...	1	1	14	...	...	3	+	+	+
Boleichthys fusiformis	...	1	13	...	....	5	18	3	8	8	+	+	+
Least darter	...	1	10	...	....	....	....	...	...	1	+	0	+
White bass	1	2	36	2	12	....	....	...	...	1	+	+	+
Yellow bass	...	1	95	...	5	....	....	...	...	....	+	+	+
Sheepshead	...	1	53	...	13	....	....	1	1	1	+	+	+
Miller's thumb	...	....	5	...	....	....	....	...	...	6	+	+	+
Cottus ricei	...	....	....	+	....	....	....	...	...	....	+	0	0
Uranidea kumlienii	..	....	....	+	....	....	....	...	...	....	+	0	0
Burbot	...	....	3	1	....	....	....	...	...	....	+	+	0

THE ILLINOIS BASIN AND THE OTHER DISTRICTS COMPARED

The key to the distribution of Illinois fishes within the state is the species list of the Illinois basin. Covering fully one half the area of Illinois, and extending in a broad belt diagonally northeast and southwest across its northern two thirds, this basin contains nearly every variety of stream, lake, pond, and marsh to be found between the

Great Lakes on the one hand and the giant flood of the Mississippi on the other, and it is to be expected that its fish population will be highly typical of Illinois as a whole. It includes, in fact, more than four fifths of the species on our Illinois list, and the special features of the various other basins and areas may best be seen by comparing them with this characteristic central basin as a type.

The following is a list of the species of the Illinois system obtained by us in collections, arranged in the order of the frequency of their appearance in 1,115 collections made from that stream and its tributary waters.

SPECIES OF THE ILLINOIS BASIN, AND NUMBER OF COLLECTIONS CONTAINING EACH

Species	Collections	Species	Collections*
Golden shiner	183	Common red-horse	90
Bluegill	179	Gizzard-shad	89
Blunt-nosed minnow	162	Brook silverside	89
Green sunfish	158	Silvery minnow	86
Black bullhead	144	Warmouth	83
Redfin (*lutrensis*)	142	Shiner	82
Large-mouthed black bass	135	Yellow bullhead	82
Spot-tailed minnow	133	Pumpkinseed	82
Tadpole cat	132	*Notropis heterodon*	81
Black crappie	130	Sucker-mouthed minnow	78
Etheostoma jessiæ	119	Yellow perch	75
White crappie	119	Striped top-minnow	75
Silverfin	116	Horned dace	72
Orange-spotted sunfish	112	Black-sided darter	70
Bullhead minnow	110	Common sucker	69
Straw-colored minnow	108	Small-mouthed black bass	69

*A cross (+) in this column indicates the known occurrence of a species which is not represented in our collections from the Illinois basin.

SPECIES OF THE ILLINOIS BASIN, AND NUMBER OF COLLECTIONS CONTAINING EACH—*continued*

Species	Collections	Species	Collections
Channel-cat	108	Blackfin	67
Common shiner	105	Black-head minnow	67
Johnny darter	100	Common top-minnow	66
Stone-roller	99	Hogsucker	61
Yellow bass	95	Grass pike	61
River chub	90	*Hadropterus phoxocephalus*	58
Blunt-nosed carp	54	Pike	17
Pirate-perch	54	*Notropis gilberti*	15
Sheepshead	53	White-nosed sucker	14
Short-nosed gar	52	Trout-perch	14
Opsopœodus emiliæ	49	*Cottogaster shumardi*	14
Chub-sucker	48	Striped sucker	13
Small-mouth buffalo	46	Red-bellied dace	13
Boleosoma camurum	45	Sauger	13
Common bullhead	42	*Boleichthys fusiformis*	13
Quillback carp	39	Silvery lamprey	12
Rainbow darter	39	Menona top-minnow	11
Short-headed red-horse	39	Fan-tailed darter	11
Long-eared sunfish	37	River carp	11
White bass	36	Least darter	10
Rock bass	35	Lake carp	10
Log-perch	35	Paddle-fish	8
Stonecat	32	Toothed herring	8
Notropis cayuga	29	*Notropis rubrifrons*	8
Red-mouth buffalo	28	Storer's chub	7

SPECIES OF THE ILLINOIS BASIN, AND NUMBER OF COLLECTIONS CONTAINING EACH—*concluded*

Species	Collections	Species	Collections
Dogfish	27	Sand darter	7
Lepomis miniatus	24	Blue-breasted darter	6
Mud-cat	22	Freckled stonecat	5
Notropis jejunus	21	Miller's thumb	5
Banded darter	21	Black-nosed dace	4
Long-nosed gar	20	*Ericymba buccata*	4
Pike-perch	20	Skipjack	3
Mud-minnow	18	Spotted shiner	3
Mongrel buffalo	17	*Lepomis ischyrus*	3
Hadropterus evermanni	3	Brindled stonecat	1
Burbot	3	Slender stonecat	1
Notropis phenacobius	2	Brook stickleback	1
Silver chub	2	Round sunfish	1
Lepomis symmetricus	2	*Lepomis euryorus*	1
Notropis anogenus	2	*Hadropterus scierus*	1
N. illecebrosus	2	Lake sturgeon	+
Viviparous top-minnow	1	Shovel-nosed sturgeon	+
Mooneye	1	Alligator-gar	+
Black-horse	1	Eel	+
Placopharynx duquesnei	1	*Ictalurus anguilla*	+
Notropis pilsbryi	1	Muskallunge	+
Hybopsis hyostomus	1	Green-sided darter	+
Blue cat	1		

Of the twenty-three Illinois species which have not been taken by us in the Illinois River or its tributaries, two are distinctively western

fishes, and occur but rarely anywhere within our limits; nine are southern species, few of which have been found as far north as the mouth of the Illinois, and one other is only southern in this state; two are northern species which barely reach our borders; five are typical fishes of the Great Lakes; one has been found by us only in the main Mississippi and the Ohio; one is a subterranean fish of strictly local occurrence; and the two remaining species are very rare in this state.

Further particulars as to the species of these various geographical groups are given in the following classified list.

ILLINOIS SPECIES NOT FOUND IN THE ILLINOIS BASIN

WESTERN (2):
- *Hybognathus nubila*
- Flat-headed chub

SOUTHERN (10):
- Harelipped sucker
- Pigmy sunfish
- Round sunfish
- *Eupomotis heros*
- *Hadropterus ouachitæ*
- *H. evides*
- *Crystallaria asprella*
- *Etheostoma obeyense*
- *E. squamiceps*
- Brindled stonecat

GREAT LAKES (5):
- Whitefish
- Lake herring
- Lake trout
- *Cottus ricei*
- *Uranidea kumlienii*

NORTHERN (2):
- Long-nosed sucker
- Nine-spined stickleback

MAIN MISSISSIPPI (1):
- White sturgeon

SUBTERRANEAN (1):
- *Chologaster papilliferus*

RARE IN ILLINOIS (2):
- Brook lamprey
- Long-nosed dace

As the Illinois basin contains 128 of the 150 species taken by us in the state, it is evident that the other and smaller basins must differ from this negatively rather than positively. Being not only much smaller, but also much less complex than the Illinois district, and offering less variety of situations for fishes as homes and places of resort, they may lack many species which find a fit environment somewhere in the Illinois or its dependent waters, but can contain relatively few not found there as well.

Regarded from this standpoint, the Michigan district is farthest removed from the Illinois ichthyologically, and of its fifty-seven species nine (16 per cent.) are wanting in the Illinois basin. The Cairo

district differs much less, eight of its one hundred and one fishes being without representation in our collections from the Illinois system. Next follows the Wabash basin in Illinois, with ninety-five species and a difference from the Illinois basin of 6.1 per cent.; the Galena district, with forty-four species and a difference of 4.6 per cent.; the Saline district, with fifty-five species, and a difference of 3.8 per cent.; and the Mississippi and its marginal area, with ninety-seven species, 3.2 per cent. of which are wanting to the Illinois streams and lakes. The Kaskaskia and the Big Muddy, on the other hand, which are scarcely more than extensions of the Illinois district downward to the southern end of the state, contain virtually no fishes not in the main district, the Kaskaskia but one out of sixty-nine (1.4 per cent.), and the Big Muddy none out of forty-two species. The Rock River district differs from the Illinois by only three species out of ninety-two (3.2 per cent.). These data are presented more compactly in the table following.

Differences between the Smaller Districts and the Illinois Basin

Districts	Species in district	Species not found in Illinois basin	Ratios of difference
Illinois	128	——	——
Michigan	57	9	.16
Cairo	101	8	.08
Wabash	95	6	.061
Galena	44	2	.046
Saline	55	2	.038
Mississippi	97	3	.032
Rock River	92	3	.032
Kaskaskia	69	1	.014
Big Muddy	42	0	.000

Five species were found in the Illinois system and not in any other—three of them minnows of the genus *Notropis* (*anogenus*, *phenacobius*, and *pilsbryi*), one of them a sunfish (*Lepomis euryorus*), and one of them a darter (*Hadropterus evermanni*). All of these species have been very rare in our collections, occurring only from one to three times each, and it was probable that they would be found, if at all, where the largest number of collections was made.

The Galena district is distinguished from the Illinois basin especially by the presence of a minnow and a darter (*Hybognathus nubila* and *Crystallaria asprella*), the latter southern in its main range, and the former western, not occurring, indeed, farther east than western Illinois. These two fishes appear in the Rock River basin also, together with another distinctively western darter (*Hadropterus evides*). In the Michigan district, besides the five lake fishes already referred to—the whitefish, the lake herring, the lake trout, and two cottoids or miller's thumbs, *Cottus ricei* and *Uranidea kumlienii*—are the brook lamprey, the long-nosed sucker, the Great Lake catfish, and one of the sticklebacks (*Pygosteus pungitius*). All but the lamprey (which is rare in Illinois) are northern species not taken by us in the Illinois valley. The Mississippi district is distinguished from the Illinois by the presence of the rare white sturgeon (*Parascaphirhynchus albus*), hitherto taken only in the Mississippi itself, and by a southern darter and a western minnow already referred to. In the Kaskaskia district we find another southern darter (*Etheostoma squamiceps*). The six fishes of the Wabash district not found in the Illinois or its tributaries, are all southern species. The Big Muddy list contains no species not found in the Illinois basin; and the Saline River district contains two southern darters (*Etheostoma squamiceps* and *E. obeyense*). And, finally, among the eight species by which the Cairo district differs from the Illinois are three southern and two western species, a cave-fish, and two species of general distribution but rare in Illinois (*Lampetra wilderi* and *Rhinichthys cataractæ*).

Thus, of the twenty-three Illinois fishes not found by us in the waters of the Illinois basin, eight are distinctively southern, six are purely northern, if we include in this number the Great Lake fishes, four are western, one is an extremely local cave-fish, and four are so rare in Illinois that their appearance in any waters is a matter of unusual chance. The limitation upon the range of these imperfectly distributed species is thus climatic and general, and not geographic

or local. This state lies on the extreme borders of their proper territory, and they are not found more commonly in our waters because climatic and other general conditions most favorable to their maintenance, here reach the vanishing point.

LISTS OF SPECIES DISTINGUISHING DIFFERENT DISTRICTS FROM THE ILLINOIS BASIN

GALENA DISTRICT (2):
- *Hybognathus nubila* (Western)
- *Crystallaria asprella* (Southern)

ROCK RIVER DISTRICT (3):
- *Hybognathus nubila* (Western)
- *Hadropterus evides* (Western)
- *Crystallaria asprella* (Southern)

MICHIGAN DISTRICT (9):
- Brook lamprey (rare)
- Long-nosed sucker (Northern)
- Whitefish (Great Lakes)
- Lake herring (Great Lakes)
- Lake trout (Great Lakes)
- Great Lake catfish (Northern)
- Nine-spined stickleback (Northern)
- *Cottus ricei* (Great Lakes)
- *Uranidea kumlienii* (Great Lakes)

MISSISSIPPI STRIP (3):
- White sturgeon (rare; Mississippi only)
- *Hybognathus nubila* (Western)
- *Crystallaria asprella* (Southern)

KASKASKIA RIVER DISTRICT (1):
- *Etheostoma squamiceps* (Southern)

WABASH DISTRICT (6):
- Harelipped sucker (rare; Southern)
- Pigmy sunfish (Southern)
- *Eupomotis heros* (Southern)
- *Hadropterus ouachitæ* (Southern)
- *Crystallaria asprella* (Southern)
- *Etheostoma squamiceps* (Southern)

SALINE RIVER DISTRICT (2):
- *Etheostoma obeyense* (Southern)
- *E. squamiceps* (Southern)

CAIRO DISTRICT (8):
- Brook lamprey
- *Hybognathus nubila* (Western)
- Long-nosed dace (rare in Illinois)
- Flat-headed chub (Western)
- *Chologaster papilliferus* (subterranean)
- Pigmy sunfish (Southern)
- *Eupomotis heros* (Southern)
- *Etheostoma squamiceps* (Southern)

RELATIONS OF EACH DISTRICT TO ALL THE OTHERS

In the foregoing discussions and analyses the fishes of the various districts have been compared with those of the largest and most central district as a type; but a fuller and more accurate idea of the composition of the fish population of Illinois and of its relations in the various hydrographic divisions of the state may be obtained by a comparison of the species of each of our ten districts successively with those of all the others. This may be done in an exact and uniform manner by determining for each pair of districts the ratio which the number of species common to the pair bears to the whole number of species occurring within the area of both the districts taken together as one. In the Galena district, for example, there are 44 species recorded, and in the Saline River basin there are 55, a total of 99; but as 26 of these species have been found in both these districts, this number has been taken twice in the above addition, and the number

of species found by us in the entire area of these two districts is consequently 73. The ichthyological affinity of these two areas is evidently to be measured by the ratio which the number of species common to both bears to the whole number of species found in either or both the areas—in this case, the ratio of 26 to 73, or 36 per cent. That is, 36 per cent. of the fishes found in either of these two districts have been found by us in both of them.

A similar analysis of the data for each of the forty-five pairs which it is possible to make up from our ten hydrographic districts, yields the material for the following table of common species and of ratios of affiliation. This table shows, in the lower left-hand part,

NUMBER OF SPECIES COMMON TO EACH PAIR OF DISTRICTS, AND RATIOS OF SUCH COMMON NUMBERS TO THE WHOLE NUMBER OF SPECIES IN EACH PAIR

Districts	1. Galena	2. Rock River	3. Illinois R.	4. Michigan	5. Mississippi	6. Kaskaskia	7. Wabash	8. Big Muddy	9. Saline	10. Cairo	Averages
1. Galena	....	45	32	20	41	40	38	28	36	37	.352
2. Rock River	42	....	68	35	69	59	63	40	47	62	.542
3. Illinois River	42	89	....	35	72	53	66	33	41	68	.52
4. Michigan	17	39	48	....	34	25	29	22	23	32	.283
5. Mississippi	41	77	94	39	....	54	61	34	42	66	.525
6. Kaskaskia	32	60	68	25	58	....	66	52	63	53	.517
7. Wabash	38	72	89	34	73	66	....	41	53	63	.534
8. Big Muddy	19	38	42	18	35	38	40	....	70	39	.398
9. Saline River	26	47	53	21	45	48	52	40	....	49	.471
10. Cairo	39	74	93	38	79	59	76	40	51	....	.521
Total species	44	92	128	57	97	69	95	42	55	101	
Number of collections	13	73	1115	20	57	41	103	10	18	95	

the number of species common to each pair of districts, and in the upper right-hand part the ratios which these numbers bear to the number of species occurring in each pair of districts taken as one. The number of species common to any two districts will be found in the lower left-hand part of the table, where the column for one district intersects with the line for the other, and the ratio of affiliation for the same pair of districts will be found in the opposite part of the table at the intersection of the line for the first with the column for the second. A simple inspection of the figures in the latter part shows at once which districts are most alike and which are most unlike in respect to their fish inhabitants. Thus, the Rock and Illinois basins and the Mississippi are the most closely related, according to these data, with affiliation ratios of 68–72 per cent. and an average of 70; and the Michigan, Galena, and Big Muddy districts are the least alike, with ratios of 20–28 per cent. and an average of 23. The two highest single ratios of ichthyological affiliation are those of the Illinois and Mississippi rivers (.72) and of the Big Muddy and Saline (.70).

The data of this table may be generalized by bringing into comparison the *average* of the ratios of affiliation for each district with those for all the rest, as shown in the column of figures farthest to the right. If the ten districts are arranged in the order of the size of their average ratios, they readily fall into two groups, the first of six districts, with relatively high ratios, and the second of four, with relatively low ratios. The first group comprises the basins of the larger rivers—the Mississippi, the Rock, the Illinois, the Kaskaskia, the Wabash, and the Ohio, each with its more or less complex system of tributaries. The average ratio for this group is 52.7 per cent. The second group is made up of small, widely separated districts, containing only small streams and lakes, except that one of them includes a little of the shallow southwestern border of Lake Michigan. In this group are the northwestern driftless area, the Saline River and its tributaries, the Big Muddy district, and the Michigan district, with an average affiliation ratio of 37.6.

If we average separately, for these groups, the ratios of each district to all the other districts of its group, we obtain for the first and higher group a ratio of mutual affiliation of 63 per cent., and for the lower group a similar ratio of 33 per cent. It is thus made clear that the districts most typical of our Illinois fauna are the first six

above mentioned, while those most individual and peculiar—least closely affiliated among themselves and each with all the others—are the Michigan, the Galena, the Saline, and the Big Muddy districts, excepting only the relation of the two last mentioned, which, as already said, is unusually close.

THE FISHES OF NORTHERN, CENTRAL, AND SOUTHERN ILLINOIS

If mere difference in latitude, involving a climatic difference within a range of five and a half degrees, limits the distribution of any of our fishes, the fact should appear upon a comparison of the species list of the northern, central, and southern sections of the state, although due caution must, of course, be exercised that other and more local causes are not confused with climatic ones. The division of the state here adopted, is shown on Map I. of the accompanying set.

The fishes of these three divisions number 119 species for northern, 123 for central, and 119 for southern Illinois, respectively. Fourteen species have been found by us only in the northern division, 9 only in the southern, and 5 only in the central, and 89 species are found in all three sections. Twelve species occur in both northern and central Illinois, but not in southern, 17 in both southern and central Illinois, but not in northern, and 4 in both the northern and southern divisions of the state, but not in the central.

FISHES OF LIMITED DISTRIBUTION IN ILLINOIS

Illinois Distribution	General Distribution
Species Peculiar to Northern Illinois	
Whitefish	Great Lakes
Lake herring	" "
Lake trout	" "
Long-nosed sucker	Northern
Notropis anogenus	"
N. phenacobius	
N. pilsbryi	Southern
Great Lake catfish	Northern
Muskallunge	"
Brook stickleback	"
Nine-spined stickleback	"
Hadropterus evides	Rather general
Cottus ricei	Great Lakes
Uranidea kumlienii	" "
Species Peculiar to Southern Illinois	
Harelipped sucker	Southern
Long-nosed dace	General; rare in Illinois
Flat-headed chub	Western
Chologaster papilliferus	Local; cave
Pigmy sunfish	Southern
Round sunfish	"
Eupomotis heros	"
Hadropterus ouachitæ	"
Etheostoma obeyense	"

FISHES OF LIMITED DISTRIBUTION IN ILLINOIS—*concluded*

Illinois Distribution	General Distribution
Species in Northern and Central Illinois, but not in Southern	
Lake carp	Northern
Notropis cayuga	General
N. rubrifrons	"
Hybopsis hyostomus	"
Stonecat	Northern and southwestern
Pike	Northern
Menona top-minnow	"
Trout-perch	"
Lepomis ischyrus	
Sauger	General
Yellow perch	Northern
Burbot	Great Lakes
Species in Southern and Central Illinois, but not in Northern	
Paddle-fish	General
Shovel-nosed sturgeon	"
Alligator-gar	Southern
Mooneye	Northern
Black-horse	General
Ericymba buccata	"
Silver chub	"
Blue cat	Southern
Ictalurus anguilla	"
Freckled stonecat	"
Brindled stonecat	General

FISHES OF LIMITED DISTRIBUTION IN ILLINOIS—*concluded*

Illinois Distribution	General Distribution
Viviparous top-minnow	Southern
Lepomis symmetricus	"
Cottogaster shumardi	General
Green-sided darter	"
Etheostoma squamiceps	Southern

An examination of the general distribution of the species of these sectional lists of Illinois fishes shows, as was to have been expected, that the distinctively northern Illinois fishes are chiefly northern in their outside range, and that those of southern Illinois are mainly southern. Thus, of the 14 especially northern Illinois fishes, 11 are northerly in their general distribution and 1 is southerly; while of the 9 distinctively southern Illinois species, 6 are southerly in their general range, 1 is western, and 1 is a cave-fish local to Illinois. The species found in the northern and central sections of the state and not in the southern are varied in their distribution, 6 of them ranging northward from Illinois, and 4 of them in all directions, while 1 has been thus far found in Illinois only. The central and southern fishes, on the other hand, comprise 7 southern species, 1 of northern and 8 of general range, and 1 whose distribution is not recorded. Including only species whose general area shows that their restricted occurrence in Illinois is a feature of their geographical distribution at large, and excluding fishes special to the Great Lakes, we have twenty-six species whose distribution in this state seems limited by conditions connected with differences in latitude merely—twelve of these species essentially northern and fourteen of them southern.

Especially Northern Species in Illinois (16):

Whitefish
Lake herring
Lake trout
Long-nosed sucker
Lake carp
Notropis anogenus
Great Lake catfish
Mooneye
Pike
Muskallunge
Menona top-minnow
Brook stickleback
Nine-spined stickleback
Trout-perch
Cottus ricei
Uranidea kumlienii

Especially Southern Species in Illinois (14):

Alligator-gar
Blue cat
Ictalurus anguilla
Freckled stonecat
Harelipped sucker
Notropis pilsbryi
Viviparous top-minnow
Pigmy sunfish
Round sunfish
Lepomis symmetricus
Eupomotis heros
Hadropterus ouachitæ
Etheostoma obeyense
E. squamiceps

USE OF LOCALITY MAPS

In the foregoing discussion of the sectional distribution of Illinois fishes no account has been taken of differences in the frequency of the occurrence of the species in the different sections in which they have been found, a single occurrence in southern Illinois, for example, counting for as much as fifty such occurrences in the northern part of the state. That highly interesting and important peculiarities of distribution are concealed by this gross method of comparison is made evident by an examination of the maps of the distribution of our collections of the various species accompanying this report, where the data are presented in a way to show, not the number of collections, it is true, in which each species was represented, but the number and distribution of localities from which the species has been obtained. From such a study of these maps it appears that the northern half or two thirds of this state is more favorable to a considerable number of species than the southern part, since these species have been taken there in a much larger number of localities; and also that a small group of species of wide general distribution has been found by us with surprising frequency in the Wabash drainage in this state as compared with that of adjacent districts.

The preference of certain species for the northern part of Illinois over the southern is clearly illustrated by the distribution maps of the following fifteen species: *Noturus flavus*, *Carpiodes thompsoni*, *Notropis cayuga*, *N. hudsonius*, *N. rubrifrons*, *Hybopsis dissimilis*, *H. kentuckiensis*, *Fundulus diaphanus*, *Percopsis guttatus*, *Eupomotis*

gibbosus, *Stizostedion canadense*, *Perca flavescens*, *Etheostoma zonale*, *Roccus chrysops*, and *Morone interrupta*. With few and slight exceptions, all the species of this varied list, representing eight families and twelve genera, are so definitely limited to the northern half of this state that one gets the impression, as he examines these maps in succession, that some invisible barrier to their southward dispersal exists in the neighborhood of the Sangamon River.

PECULIARITIES OF DISTRIBUTION IN THE LOWER ILLINOISAN GLACIATION

That the distribution of these more northerly species is not limited by the watersheds is shown by the fact that they range across the state indifferently into all the stream systems of northern Illinois. It is not until we compare with our distribution maps a map of the surface geology of the state (Map III.) that we find a plausible explanation of a part, at least, of this peculiar distribution, for all but one of the species above mentioned are wholly excluded from the area of this glaciation, and this excepted species (*Hybopsis dissimilis*) appears in but one locality within the lower glaciation, and that a short distance within its border, on the upper Kaskaskia.

Especially significant in this relation are several cases in which species of this list range southward in the eastern part of the state upon the upper tributaries of the Kaskaskia and the Embarras, for in so doing they simply follow southward the course of the Shelbyville moraine which forms the boundary between the Wisconsin and the lower Illinoisan glaciations in east-central Illinois. The maps for *Noturus flavus*, *Hybopsis dissimilis*, *H. kentuckiensis*, and *Stizostedion canadense* are examples.

That this coincidence of distribution and surface geology points to a true explanation is further shown by the maps for twenty-two other species which range more definitely to the southward than the foregoing twelve, but which nevertheless avoid the southern glaciation more or less completely and to an unmistakable degree. For example, 19 of our 94 collection localities for the hogsucker (*Catostomus nigricans*) lie below the Springfield parallel, but only three of them are in the lower Illinoisan glaciation, and these are barely within its borders. Of our thirty localities for the short-headed redhorse (*Moxostoma breviceps*) only two are in this glaciation, and these are near its boundaries on the Embarras and the Kaskaskia. The very abundant minnow *Campostoma anomalum* was taken by us from

one hundred and sixty localities, thirty-one of which are south of the Sangamon and eight of them from the non-glaciated area of the Cairo district, but only one of the entire number is within the lower glaciation, and that is on the upper Kaskaskia, just across the limiting moraine. The map for *Notropis cornutus* shows one hundred and sixty-one localities from which collections of this species were made, ninety of them below the Sangamon and twenty-nine in the Cairo district, but only three are in the southern glaciation. Other species testifying to the same effect will be found in the following list of fishes absent from this characteristic southern Illinois district.

Illinois Fishes Rare or wanting in the Lower Illinoisan Glaciation

Short-nosed gar
Common bullhead
Stonecat
Lake carp
Quillback carp
Common sucker
Hogsucker
Short-headed red-horse
Stone-roller
Red-bellied dace
Notropis cayuga
N. heterodon
Straw-colored minnow
Notropis gilberti
Spot-tailed minnow
Common shiner
Notropis jejunus
N. rubrifrons
Spotted shiner
Storer's chub
River chub
Pike
Menona top-minnow
Trout-perch
Pumpkinseed
Small-mouthed black bass
Sauger
Yellow perch
Banded darter
Rainbow darter
Fan-tailed darter
White bass
Yellow bass
Miller's thumb

Fishes Tolerant of the Lower Illinoisan Glaciation

Dogfish
Channel-cat
Yellow bullhead
Black bullhead
Mud-cat
Tadpole cat
Brindled stonecat
Chub-sucker
Striped sucker
Silvery minnow
Blunt-nosed minnow
Opsopœodus emiliæ
Golden shiner
Bullhead minnow
Silverfin
Shiner
Blackfin
Ericymba buccata
Silver chub
Grass pike
Common top-minnow
Viviparous top-minnow
Pirate-perch
White crappie
Round sunfish
Warmouth
Green sunfish
Long-eared sunfish
Orange-spotted sunfish
Large-mouthed black bass
Black-sided darter
Boleosoma camurum
Sand darter
Etheostoma jessiæ
Boleichthys fusiformis

Among the ninety-eight Illinois species for which distribution maps have been prepared, thirty-four belong clearly to this group of fishes which seem to avoid the conditions common to the flat gray lands of the southern part of the state. Thirty-five species, on the other hand, are distributed over this glaciation in a way to indicate a tolerance of its conditions if not an indifference to them, the data concerning the remaining twenty-nine species being ambiguous or indecisive in this respect.

Two facts concerning the soil and waters of the lower Illinoisan glaciation may be held to account, at least in part, for the failure of certain species of fishes to thrive in its streams. Compared with the other regions of the state, this oldest of our glaciation areas has developed its drainage system to a point such that the rainfall runs off rapidly in a large number of small streams, leaving no marshes or ponds to hold back the waters during periods of dry weather. It is a level country whose streams fill up quickly and run down rapidly, the smaller ones drying up completely during the midsummer drought, which is here more marked than farther north. These variable and temporary creeks are, of course, less favorable to the maintenance of a varied and permanent fish population than the waters of the earlier Illinoisan or the Wisconsin areas.

As a further consequence of its geological antiquity, involving degenerative chemical changes and a long-continued leaching, the soil of this lower glaciation has become an extremely fine-grained, light-colored clay which, when compact, sheds water almost completely, but which washes into the streams as a fine detritus that remains persistently in suspension and renders the waters very turbid for a long time after a rain. Standing pools, indeed, never become even approximately clear. So persistent is this turbidity, due to very finely divided matter in suspension, that the chemists of the Water Survey find it almost impossible to free the water wholly from suspended solids even by repeated filtration. Furthermore, this soil has a definitely acid reaction, to which is due a notable physical difference between the soils of this area and those of the later glaciations west and north of it. A surplus of lime in a soil coagulates or granulates it, causing its ultimate particles to cohere in larger granules, while in an acid soil this effect is entirely wanting. This lack of granulation in a very finely divided soil increases, of course, the per-

manent muddiness of its waters as compared with those of the other areas in which lime in the soil renders it alkaline.

The acidity of this southern soil seems not to be of a kind or amount to affect the surface waters sensibly and directly, since the water samples from this region analyzed by the State Water Survey show a soft water, slightly alkaline, and chemically unobjectionable as a medium for fishes.

CLASSIFICATION AND USE OF ECOLOGICAL DATA

That these conditions are a part, at least, of the cause of the phenomenal distribution of southern Illinios fishes may be shown by a comparison of our ecological data for the fishes of the two lists—one composed of those adapted to the conditions of the lower Illinoisan glaciation and the other of those avoiding them. In the organization of the data of our collections of Illinois fishes, those concerning the character of the water body in which collections were made were classified in a way to show the number of collections of each species taken from each class of situation. By reducing these numbers to ratios of frequency of occurrence, we have a means of exhibiting the preference of species with respect to the situations in which each occurs. *Pimephales notatus*, for example, was found twenty times over a muddy bottom to thirty-four over a bottom of mud and sand, and to forty-six over a bottom of rock and sand. *Aphredoderus sayanus*, on the other hand, was found sixty-two times on a muddy bottom to nineteen times in each of the other situations.

By tabulating data of this description separately for each of the two lists of species referred to—thirty-four species in the one list and thirty-five in the other—and averaging the ratios for each group separately, significant evidence was obtained of the factors which affect the distribution of these fishes.

The species which distribute themselves freely over southern Illinois are those which are generally tolerant of turbid waters, as shown by the fact that 32 per cent. of all our collections of this group came from muddy streams and ponds, 34 per cent. from situations where the bottom was composed largely of rock and sand, and 24 per cent. from a bottom of sand and mud. The species avoiding the central area of southern Illinois, on the other hand, are, as a rule, intolerant

of muddy waters, only 10 per cent. of all our data-bearing collections of this group coming from such situations, while 61 per cent. of them were from bottoms of rock and sand, and 29 per cent. from those of sand and mud. It is consequently clear that the suspended detritus of the streams of southern Illinois and the clay and mud of which their banks and bottoms are commonly composed, are an important part, at least, of the cause of the smaller variety of fishes in these waters; and these conditions trace back through the character of the soil to the geological history of the central part of southern Illinois.

FISHES OF THE OHIO AND OF THE MISSISSIPPI DRAINAGE

A comparison and classification of our distribution maps from another point of view enables us further to distinguish two rather definite groups of species coincident in great measure, but not wholly so, with the two groups which we have found in an opposite relation to the lower Illinoisan glaciation. No less than 27 of our species have either an exclusive or at least a strongly preponderant distribution in the Mississippi drainage in the western and northern parts of the state, while 8 species, on the other hand, are very definitely preponderant in the Ohio drainage in the southern and eastern parts. Nineteen of the 27 species of the first list are also on the list of species excluded from the region of the lower Illinoisan glaciation, while 6 of the 8 species of the second list are also on that of species distributed freely through this southern Illinois district. We have evidence here of another influence strongly affecting distribution, coincident in part with that already discussed, but independent of it also in part, the two causes, or sets of causes, operating together to determine the actual range of most of the species of limited distribution in this state.

The impression produced by an examination of the two sets of maps for the fishes above mentioned, is that of a small group of species, on the one hand, which enter the state from the south and east by way of the Wabash and the smaller tributaries of the Ohio, and, on the other hand, of a much larger group, most of which have entered the state from the west and north, making their way to its interior mainly by the Illinois and the Rock, but sometimes by the Kaskaskia and the Big Muddy also. Species of the Ohio group sometimes seem to spread into the headwaters of adjacent streams,

especially into the branches of the Kaskaskia where these come nearest to the Embarras, and into those of the Big Vermilion of the Illinois which are nearest to the Little Vermilion of the Wabash. Some species, however, remain carefully within the tributaries of the Wabash system.

It seems possible that this appearance of an approach to the state and entrance upon its territory from opposite directions is not altogether deceptive, and that the annual movements of the fishes of the state, up the streams at the time of the spring floods, downwards with the recession of the waters, and still farther downwards, for many species, into deeper water in the winter, may take these two contingents of our fish population in opposite directions, from and towards local centers of population for the species, situated on opposite sides of the state. Whether and where such local centers of population actually exist, is a question which can not be answered definitely for lack of numerical or statistical data in the faunal lists and other literature of geographical distribution for the surrounding states. If they exist, the Wabash fishes would constitute one such system, and those of the Mississippi and its tributaries, another.

If we may speculate still further upon this subject, we may perhaps surmise that a general critical analysis of the fish population of the larger area of which Illinois forms the central part, would enable us to distinguish fairly well-defined districts, each with its characteristic assemblage of prevalent species, so associated and ecologically related as to form a balanced assemblage of species, all so adjusted to each other and so advantageously placed in their environment as to constitute a closed system, which the characteristic species of adjacent areas can not enter, or in which they can not permanently remain.

Distribution chiefly in the Ohio Drainage

Brindled stonecat
Green-sided darter
Boleichthys fusiformis
Chub-sucker
Pirate-perch
Notropis illecebrosus
Ericymba buccata
Long-eared sunfish

Distribution chiefly in the Mississippi Drainage

Short-nosed gar
Stonecat
Lake carp
Notropis cayuga
White bass
Yellow bass
Common bullhead
Short-headed red-horse

Spot-tailed minnow
Notropis rubrifrons
Spotted shiner
Pike
Menona top-minnow
Trout-perch
Pumpkinseed
Sauger
Yellow perch
Banded darter
Red-bellied dace
Notropis gilberti
Long-nosed gar
Dogfish
Mongrel buffalo
Black-head minnow
Hybognathus nubila
Redfin
Rock bass

BOUNDARY BETWEEN NORTHERN AND SOUTHERN SPECIES

Recurring next to the distinction made on another page between northern and southern fishes whose areas extend into Illinois but not beyond, and comparing the distribution of these groups within the state, as given on Map CIII., we see that northern and southern species meet and mingle in the western part of the state from Meredosia to Pekin on the Illinois, and from Quincy to Dallas City on the Mississippi, but that in eastern Illinois they are separated by a wide interval extending from Cook county to the mouth of the Embarras, in which interval we have never taken any representative of either group.

The distinctively southern species, although most abundant south of the line 28° 30″, nevertheless go up the Wabash to the Embarras, up the Kaskaskia to Shelby county, up the Mississippi to Henderson county, and up the Illinois to Pekin, also following the branches of the Sangamon to Logan county. The northern species, on the other hand, although most abundant above 40° 20″, come down the Illinois to Meredosia, and down the Mississippi to Quincy.

The boundary between the northern and southern species thus appears as a broad belt some fifty miles in width, extending two thirds of the way across the state just above its center, but widening to a distance of one hundred and seventy-five miles on the eastern boundary.

GENERAL FEATURES OF ECOLOGICAL DISTRIBUTION

In addition to the general distribution of Illinois fishes over the North American continent, their general or partial distribution within the state, and the unevenness of their distribution over the different divisions of the state, hydrographic, climatic, and geological, there are also recognizable differences and inequalities of distribution corresponding to the size of the water bodies in which the

species are found, to the nature of the bottom and the consequent clearness and purity of the waters, and to the existence and rate of current or flow in the waters inhabited by them. In this class of divisions, geological distribution merges into ecological relation, the distribution of species being no longer by geological areas, but by ecological situations. In this sense two species may occupy precisely the same territory without ever coming into any effective contact with each other, because they are differently related to certain features of their environment.

As an explanation of the more general facts of distribution requires an analysis and interpretation of continental, terrestrial, and even cosmic agencies affecting it, so an understanding of what we may call the ecological distribution of a species requires a corresponding analysis of the ecological features of the region. Such an analysis can here be carried but a little way, since the ecological data borne by our collections are only of a very general type; but such as they are, they may, if used with discretion, add definiteness and detail and some degree of statistical precision to our knowledge of this part of the subject.

My statistics of associate occurrence exhibit in the most interesting manner the frequent tendency of closely allied species inhabiting the same territory to avoid each other's company and thus to evade competition with one another by the choice of different haunts and situations within the area of their common habitation. In consequence of this tendency, we sometimes find widely unlike species more closely and commonly associated in our collections than like, the ecological repulsion of each for its similars bringing dissimilars together into more or less definite associate groups. The sunfishes proper, for example—that is, the *Centrarchidæ* exclusive of the black bass—although a homogeneous group of species as to form and external structure, are a diverse assemblage as to ecological relationships. If we compare the proportionate frequency with which the closely similar species of the genus *Lepomis* have been taken together in our collections—in the same haul of the net, or from the same situation at the same time—with the frequency of associate occurrence of the widely dissimilar species of the other genera of the family, we find that the unlike species have been taken together much more frequently than the like—in a ratio of $1\frac{1}{2}$ to 1,—that the species of *Lepomis* have,

indeed, been taken in company with species of other genera considerably more frequently than with each other. The sunfishes, consequently, are not an associate group, but tend to disperse themselves over a large variety of ecological situations, those least like each other being most likely to meet on common ground where their unlike capacities enable them to live together in a non-competitive way. Other striking examples of this reaction might be pointed out in the suckers, the minnows, the catfishes (especially the bullheads), and the top-minnows.

Ninety-seven of our species have been collected in large enough numbers, and from a sufficient variety of locations, to give us data for comparison with reference to the general character and size of the water bodies which they prefer; 62 species furnish available data concerning the bottom or substratum of these water bodies; and 49 species, data concerning current and rate of flow. The numbers of collections for the various species covered by these figures vary greatly from a minimum of 10 collections of a species to a maximum of 376. Unfortunately, the larger and more important fishes are commonly represented by the smaller numbers of collections, and statements made concerning these are less likely to be found fairly accurate and generally correct than are those concerning the smaller fishes, represented by larger numbers of collections.

One available set of our data may best be presented in tabular form, for such use as the student may wish to make of them; and to this table we add, as an illustration of its use, only a few statements concerning the more conspicuous ecological groups of our Illinois fishes.

By assorting the species according to the size of the ratios of frequency of occurrence for each class of situations distinguished in this table, we may separate those strongly preferring the given situation from those apparently avoiding it. In this way we learn that the species occurring in our collections with disproportionate frequency in the larger rivers of the state are the mud-cat (*Leptops olivaris*), one of the river carp (*carpio*), the toothed herring (*Hiodon tergisus*), and the sheepshead (*Aplodinotus*), among the larger fishes; and a small darter (*Cottogaster shumardi*), the trout-perch (*Percopsis guttatus*), and a minnow (*Hybopsis dissimilis*) among the smaller fishes.

The principal larger fishes of the smaller rivers make a much longer list, comprising the hogsucker, two of the native carp (*velifer* and *difformis*), a species of red-horse (*aureolum*), the rock bass, and the small-mouthed black bass; and the principal smaller species are six darters (*Etheostoma zonale*, *Hadropterus phoxocephalus*, *H. aspro*, *Diplesion blennioides*, *Etheostoma cæruleum*, and *Ammocrypta pellucida*), a stonecat (*Noturus flavus*), and *Hybopsis kentuckiensis*, and four other minnows, all of the genus *Notropis* (*rubrifrons*, *gilberti*, *blennius*, and *cornutus*)—their ratios running from 70 per cent. for *rubrifrons* to 41 per cent. for *cornutus*.

The species of our list which have from 50 to 100 per cent. of their representatives in creeks, as illustrated by our collections, include three sunfishes (the green sunfish, the round sunfish, and the long-eared sunfish), three suckers (the common sucker, the chub-sucker, and the striped sucker), four darters, ten minnows, and the brindled stonecat.

The larger species found most abundantly in lakes, ponds, and other stagnant waters were the common bullhead, the buffaloes, the yellow perch, the white bass, the yellow bass, the large-mouthed black bass, and five sunfishes (both crappies, the warmouth, the pumpkinseed, and the bluegill); and the smaller kinds were the smallest of our fishes (*Microperca punctulata*), another darter (*Boleichthys fusiformis*), two minnows (*Notropis cayuga* and *N. heterodon*), the mud-minnow, and a killifish (*Fundulus dispar*).

Turning next to the 62 species for which our data of preference or avoidance of a muddy bottom are available, we find 7 species whose ratios of frequency of occurrence in such situations range from 43 to 88 per cent., and which may consequently be called limophagous fishes. These are the warmouth sunfish, the black and the yellow bullheads, the pirate-perch, a single darter (*Boleosoma camurum*), and two minnows, the golden shiner and the common shiner (*Notropis cornutus*.)

It is interesting to find, by an examination of our maps, that all these 7 species are freely distributed over the lower Illinoisan glaciation of the southern part of the state, where, as we have already shown, only fishes indifferent to a peculiarly persistent turbidity of the water are likely to occur.

By selecting from this same list of 62 species those with the lowest ratios of frequency over a muddy bottom, we get 13 species (with ratios of 4 to 10 per cent.) which evidently avoid such situations; and these, again, are without exception so distributed that the area of the lower Illinoisan glaciation is almost never entered by them. These are one of the native carp (*velifer*), a species of red-horse (*aureolum*), the small-mouthed black bass, two darters (*Hadropterus phoxocephalus* and *Etheostoma cæruleum*), five minnows (*Campostoma anomalum*, *Notropis heterodon*, *Ericymba buccata*, *Hybopsis kentuckiensis*, and *Notropis blennius*), two stonecats, and the little brook silverside (*Labidesthes*).

A more precise statement and a fuller discussion of the ecological relations of our fishes, including statistics of companionship for the various species, as shown by the frequency of their joint occurrence in collections, must be left for later contributions.

Attention may be profitably called, in conclusion, to the economic significance of the details of distribution of the various species as influenced both by geographical and ecological conditions, since a proper understanding and application of these facts will prevent wasteful efforts to introduce species where they do not belong and can not thrive. Indeed, the more detailed our knowledge of favorable, and even optimum, conditions for the different species, and the more exact, also, our acquaintance with the relations of each species of fish to its companion species in any associate assemblage, the more intelligent, and hence the more successful, in the long run, will be our efforts to extend the range and multiply the numbers of the more useful species and to lessen the numbers of those especially injurious.

ECOLOGICAL TABLE

ALL ILLINOIS SPECIES WITH AT LEAST TEN AVAILABLE RECORDS EACH*

Jordan and Evermann Nos.	Species	Water (97 species)					Current (49 species)				Bottom (62 species)			
		Available collections	Larger rivers	Smaller rivers	Creeks	Lakes, ponds, etc.	Available collections	Swift to moderate	Sluggish to stagnant	Variable	Available collections	Mud	Rock and sand	Mud and sand
1	Long-nosed gar	35	25	19	7	22	....	....	....	....	....	....	....	....
2	Short-nosed gar	57	28	24	4	25	....	....	....	....	....	....	....	....
5	Dogfish	37	18	7	6	30	....	....	....	....	....	....	....	....
7	Channel-cat	171	20	32	27	8	31	68	19	13	75	21	44	35
5	Yellow bullhead	122	7	6	37	23	14	36	43	21	35	43	34	23
7	Common bullhead	48	15	5	4	44	....	....	....	....	....	....	....	....
8	Black bullhead	244	8	21	37	26	38	37	53	10	56	54	46	....
1	Mud-cat	30	53	21	5	8	....	....	....	....	....	....	....	....
2	Stonecat	41	10	53	34	....	15	60	13	26	24	8	58	34
3	Tadpole cat	193	17	5	23	41	21	48	43	9	45	29	27	44
1	Brindled stonecat	30	3	36	60	....	....	....	....	....	13	8	62	30
1	Red-mouth buffalo	39	13	....	9	48	....	....	....	....	....	....	....	....
2	Mongrel buffalo	19	17	....	7	45	....	....	....	....	....	....	....	....
4	Small-mouth buffalo	52	14	12	4	49	....	....	....	....	....	....	....	....
5	River carp	15	47	....	8	10	....	....	....	....	....	....	....	....
6	Blunt-nosed carp	102	9	42	30	12	16	50	25	25	47	21	36	43
8	Quillback carp	70	10	50	19	5	19	47	32	21	28	4	60	36

*The figures of this table, except those in the columns for available collections, are atios of frequency of the species in our collections, computed with due reference to the omparative numbers of collections of all kinds made in each situation. .

ECOLOGICAL TABLE—*continued*

ALL ILLINOIS SPECIES WITH AT LEAST TEN AVAILABLE RECORDS EACH

Jordan and Evermann Nos.	Species	Water (97 species)					Current (49 species)				Bottom (62 species)			
		Available collections	Larger rivers	Smaller rivers	Creeks	Lakes, ponds, etc.	Available collections	Swift to moderate	Sluggish to stagnant	Variable	Available collections	Mud	Rock and sand	Mud and sand
289	Common sucker	132	3	19	71	1	49	39	47	14	79	13	44	43
294	Hogsucker	99	4	63	25	4	71	20	63	17	59	....	54	46
302a	Chub-sucker	131	9	12	57	14	23	52	48	....	57	32	39	29
303	Striped sucker	46	2	31	53	3	....	....	....	....	19	26	32	42
305	White-nosed sucker	18	7	44	20	6	....	....	....	....	....	....	....	....
314	Common red-horse	143	9	32	40	4	47	57	28	15	65	6	55	39
319	Short-headed red-horse	55	13	25	15	22	....	....	....	....	14	14	43	43
328	Stone-roller	195	3	37	55	1	65	63	23	14	105	7	57	36
334	Red-bellied dace	23	10	....	71	....	....	....	....	....	....	....	....	....
340	Silvery minnow	183	12	36	32	7	30	47	40	13	67	33	40	27
349	Black-head minnow	95	14	30	48	4	12	50	42	8	44	25	41	34
350	Blunt-nosed minnow	376	5	34	43	12	108	50	34	16	202	20	46	34
355	Horned dace	151	4	28	63	2	42	48	36	16	81	17	47	36
391	*Opsopœodus emiliæ*	40	13	6	36	32	....	....	....	....	....	....	....	....
394	Golden shiner	303	12	17	29	32	28	32	57	11	82	44	29	27
398	Bullhead minnow	187	17	31	28	7	36	67	17	16	62	11	44	45
405	*Notropis cayuga*	29	....	13	26	57	13	54	38	8	15	....	27	73
406	*N. heterodon*	92	19	1	19	60	....	....	....	....	14	7	22	71
408	Straw-colored minnow	185	7	44	37	3	63	49	26	25	103	10	50	40

ECOLOGICAL TABLE—*continued*

ALL ILLINOIS SPECIES WITH AT LEAST TEN AVAILABLE RECORDS EACH

Jordan and Evermann Nos.	Species	Water (97 species)					Current (49 species)				Bottom (62 species)			
		Available collections	Larger rivers	Smaller rivers	Creeks	Lakes, ponds, etc.	Available collections	Swift to moderate	Sluggish to stagnant	Variable	Available collections	Mud	Rock and sand	Mud and sand
20	*Notropis gilberti*	30	2	49	43	2	....	....	....	....	18	11	45	44
26	*N. illecebrosus*	11	....	....	100	....	....	....	....	....	....	....	....	....
28	Spot-tailed minnow	147	28	5	2	39	....	....	....	....	10	20	80	....
32	Redfin	163	24	32	20	14	13	46	38	16	55	27	40	33
48	Silverfin	268	6	39	40	4	65	54	26	20	126	13	56	31
56	Common shiner	178	2	41	50	4	76	45	36	19	102	44	48	8
76	*Notropis jejunus*	51	27	19	13	11	....	....	....	....	12	25	67	8
35	Shiner	206	20	36	15	11	23	57	30	13	48	21	64	14
49	*Notropis rubrifrons*	13	4	70	26	....	11	45	18	36	11	....	82	18
48a	Blackfin	208	3	32	65	....	69	41	45	14	109	17	43	40
49	*Ericymba buccata*	74	1	18	81	....	14	43	29	28	38	8	63	29
51	Sucker-mouthed minnow	159	5	36	53	1	53	53	24	23	92	15	51	34
58	Spotted shiner	11	50	27	22	....	....	....	....	....	....	....	....	....
63	Silver chub	41	5	29	66	....	13	77	15	7	20	30	55	15
64	Storer's chub	28	21	32	11	10	....	....	....	....	....	....	....	....
66	River chub	129	4	41	51	1	55	53	24	23	74	8	43	49
74	Toothed herring	10	46	....	....	16	....	....	....	....	....	....	....	....
77	Gizzard-shad	105	17	32	7	20	....	....	....	....	22	23	55	22
79	Mud-minnow	34	7	24	8	49	....	....	....	....	....	....	....	....

ECOLOGICAL TABLE—*continued*

ALL ILLINOIS SPECIES WITH AT LEAST TEN AVAILABLE RECORDS EACH

Jordan and Evermann Nos.	Species	Water (97 species)					Current (49 species)				Bottom (62 species)			
		Available collections	Larger rivers	Smaller rivers	Creeks	Lakes, ponds, etc.	Available collections	Swift to moderate	Sluggish to stagnant	Variable	Available collections	Mud	Rock and sand	Mud and sand
922	Grass pike	111	7	16	34	30	14	36	57	7	29	38	21	4
939	Menona top-minnow	17	....	....	42	49	....	....	....	....	....	....	....	..
966	Striped top-minnow	83	11	....	3	72	....	....	....	....	....	....	....	..
967	Common top-minnow	208	6	25	49	12	34	41	50	9	81	32	42	2
1000	Viviparous top-minnow	17	12	21	32	12	....	....	....	....	....	....	....	..
1145	Trout-perch	15	52	....	4	19	....	....	....	....	....	....	....	..
1147	Pirate-perch	100	18	5	42	21	14	21	72	7	37	62	19	1
1177	Brook silverside	120	13	28	13	36	16	31	44	25	21	10	62	2
1381	White crappie	166	15	19	17	34	14	64	29	7	43	35	49	1
1382	Black crappie	179	17	16	10	42	....	....	....	....	28	25	50	2
1383	Round sunfish	11	....	....	69	30	....	....	....	....	....	....	....	..
1385	Rock bass	48	7	49	24	13	20	55	15	30	27	....	48	5
1387	Warmouth	122	12	17	12	45	....	....	....	....	17	88	12	..
1391	Green sunfish	313	7	25	52	11	80	39	45	16	156	28	41	3
1397	*Lepomis miniatus*	23	10	....	11	41	....	....	....	....	....	....	....	..
1399	Long-eared sunfish	112	2	12	76	4	17	41	47	12	41	37	63	..
1400	Orange-spotted sunfish	174	12	25	34	20	21	38	38	24	60	30	35	3
1403	Bluegill	214	16	10	7	54	....	....	....	....	24	25	58	1
1408	Pumpkinseed	85	6	17	4	56	....	....	....	....	....	....	....	..

ECOLOGICAL TABLE—*continued*

ALL ILLINOIS SPECIES WITH AT LEAST TEN AVAILABLE RECORDS EACH

Jordan and Evermann Nos.	Species	Water (97 species)					Current (49 species)				Bottom (62 species)			
		Available collections	Larger rivers	Smaller rivers	Creeks	Lakes, ponds, etc.	Available collections	Swift to moderate	Sluggish to stagnant	Variable	Available collections	Mud	Rock and sand	Mud and sand
409	Small-mouthed black bass	100	6	43	23	19	40	55	18	27	50	6	68	26
410	Large-mouthed black bass	211	8	20	17	40	19	58	26	16	48	19	54	27
413	Pike-perch	36	16	10	8	33	....	....	....	....	....	....	....	....
414	Sauger	16	36	....	4	25	....	....	....	....	....	....	....	....
415	Yellow perch	83	20	7	3	51	....	....	....	....	....	....	....	....
417	Log-perch	60	10	38	27	19	14	93	7	....	20	....	100	....
418	*Hadropterus phoxocephalus*	85	7	57	27	3	32	87	13	....	48	6	94	....
421	Black-sided darter	159	6	42	47	1	49	70	30	....	76	16	84	...
436	*Cottogaster shumardi*	16	55	....	4	18	....	....	....	....	....	....	....	....
443	Green-sided darter	24	....	46	53	....	....	....	....	....	....	....	....	....
446	Johnny darter	234	3	25	53	16	71	68	32	....	126	11	89	....
448	*Boleosoma camurum*	107	9	23	42	17	17	41	59	....	39	60	40	....
450	Sand darter	19	13	47	39	....	....	....	....	....	....	....	....	....
461	Banded darter	32	3	74	23	....	18	89	11	....	19	11	89	....
474	*Etheostoma jessiæ*	158	20	19	16	24	12	83	17	....	31	23	67	....
477	Rainbow darter	80	3	44	45	1	29	83	17	....	37	8	92	....
489	*Etheostoma squamiceps*	10	....	35	64	....	....	....	....	....	....	....	....	....
490	Fan-tailed darter	30	9	....	87	4	....	....	....	....	11	....	100	....

ECOLOGICAL TABLE—*concluded*

ALL ILLINOIS SPECIES WITH AT LEAST TEN AVAILABLE RECORDS EACH

Jordan and Evermann Nos.	Species	Water (97 species)					Current (49 species)				Bottom (62 speci			
		Available collections	Larger rivers	Smaller rivers	Creeks	Lakes, ponds, etc.	Available collections	Swift to moderate	Sluggish to stagnant	Variable	Available collections	Mud	Rock and sand	
1494	*Boleichthys fusiformis*..	56	1	12	24	62	....	....	....	....	21	33	67	..
1497	Least darter.....	12	....	....	4	95	....	....	....	....	....	....	....	..
1529	White bass.....	56	28	....	8	46	....	....	....	....	....	....	....	..
1531	Yellow bass.....	100	20	4	....	52	....	....	....	....	....	....	....	..
1871	Sheepshead.....	57	29	16	1	27	....	....	....	....	....	....	....	..

GENERAL SUMMARY

The principal conclusions of this article may be thus summarized:

1. The 150 native species of Illinois fishes here recognized, are so distributed within and without the state as to indicate an unequal commingling of the faunæ of the surrounding territories, southeastern species preponderating over southwestern, northeastern over northwestern, eastern over western, and southern over northern.

2. The Illinois basin may be taken as typical, in its fish population, of the ichthyology of the whole state—occupying, as it does, a central position, including more than half the area of the state, and containing a great variety of waters and situations fit for the habitation of fishes, and more than four fifths of the species found anywhere in Illinois. The more important fishes of the state not known from this basin are a few distinctively northern species, most of which are peculiar to the Great Lakes, and a few southern species which do not range as far north, in this state, as the mouth of the Illinois. The

remainder are very rare in our territory, most of them coming from the west and south, and they are extremely insignificant elements of our fish fauna.

3. If the ten stream systems of the state be brought into comparison one with another, it appears that the six larger areas, containing the largest streams and presenting the greatest variety of situations, are much more closely affiliated ichthyologically than are the four smaller areas. The least closely affiliated with each other and with all the rest are the Michigan district of northeastern Illinois and the Big Muddy basin in the southwest. The closest relations are those between the Illinois, the Rock, and the Mississippi.

4. In the absence, in Illinois, of geographical barriers to the dispersal of fishes, the causes influencing their distribution are climatic, geologic, and ecological. As Illinois extends through 5.5° of latitude, differences of climate between the northern and the southern sections of the state are sufficient to affect, in considerable measure, the distribution of its plant and animal species—differences which, in its ichthyology, express themselves in the presence in northern Illinois, but not in southern, of 17 species of general northward range; and in southern Illinois, but not in northern, of 14 species of general southward range. These two groups of species meet and mingle in the great north and south rivers of the western half of the state, in an area of common occupation about fifty miles in width, from the latitude of Springfield northward; while on the eastern boundary of the state, occupied by small streams of various direction, these groups are separated by an interval of about a hundred and seventy-five miles over which no representative of either group has been taken.

5. Geological limitations to the dispersal of fishes are illustrated by peculiarities of distribution in southern Illinois as related to the area of the lower Illinoisan glaciation, which 34 species evidently avoid while 35 other species enter upon it freely and inhabit it successfully. A comparison of the ecological relations of these two groups of species as represented by our collection records, shows that they are strongly distinguished by the repugnance of the first group, and the indifference of the second, to waters with a muddy bottom, collections of the first group having been made from such situations in an average ratio more than three times as great as that for the second. The waters of this region, on the other hand, are re-

markably and persistently turbid, never clearing themselves spontaneously. This is owing in part to the extremely fine division of the soil, and in part to its generally acid character and the consequent lack of "granulation," or cohesion of its ultimate particles in granules, such as occurs in the alkaline soils of the other geological areas of the state. The surface waters of the district are soft and slightly alkaline, but contain much silica, and much solid matter in suspension which it is extremely difficult to remove completely by any ordinary filtering or precipitation process. The inference is plain that it is to this condition of the waters—due to the geological history of the soil of this region—that the unequal distribution of these fishes is largely to be attributed.

6. In consequence of another clearly recognizable inequality of distribution, partly coincident with the two preceding and partly independent of them, two additional groups may be distinguished; one of 8 species, distributed in this state mainly through the Ohio and Wabash drainage, and the other of 27 species, distributed through the Mississippi and its more northerly tributaries. The general distribution throughout the country at large of each of these two groups of species is quite varied, and offers no hint of a reason for these differences in Illinois. Two hypothetical explanations are suggested—the first presupposing different centers of population outside the state, from and towards which these species move, into and out of Illinois streams, with the spring rise, summer recession, and winter cooling of the waters, one of these centers to the west and north, and one to the east and south; and the second presupposing an organization of the fish population into more or less distinct communities of mutually. well-adjusted species, each community so adapted to its environment that members of adjacent communities can not successfully intrude upon its territory.

7. An analysis of our statistical data of ecological distribution gives us many instances of a marked difference in preference of situation between nearly related species inhabiting the same area, the effect of which is to break the force of a competition between these species such as would prevail if they were similarly distributed ecologically as well as geographically. Closely related species are, as a consequence, often found much less frequently associated in their common territory than either is with widely unlike species of the same geographical range. Exceptions to this rule are found

where similar species occupy adjacent areas of distribution which merely overlap by their borders.

8. A table of the broader ecological relations of 97 species of Illinois fishes is made the basis of a few general statements, but that subject as a whole is reserved for more detailed treatment elsewhere.

List of Maps

The general map of the distribution of collections (Map IV.) shows, by the location of the red spots, all the localities from which collections of fishes have been made by us in the work of the Natural History Survey. The distribution maps for the various species indicate in the same way all the localities from which representatives of the species have been taken. *For an accurate idea of the significance of these species maps, each should be compared with Map IV.*

The following numbered list of the counties of the state corresponds to the figures on these maps.

1. Jo Daviess
2. Stephenson
3. Winnebago
4. Boone
5. McHenry
6. Lake
7. Cook
8. Du Page
9. Kane
10. DeKalb
11. Ogle
12. Lee
13. Carroll
14. Whiteside
15. Rock Island
16. Mercer
17. Henry
18. Bureau
19. Putnam
20. La Salle
21. Kendall
22. Grundy
23. Will
24. Kankakee
25. Iroquois
26. Ford
27. Livingston
28. Marshall
29. Woodford
30. Stark
31. Peoria
32. Knox
33. Warren
34. Henderson
35. Hancock
36. McDonough
37. Fulton
38. Mason
39. Tazewell
40. McLean
41. Vermilion
42. Champaign
43. Piatt
44. Dewitt
45. Logan
46. Menard
47. Cass
48. Schuyler
49. Brown
50. Adams
51. Pike
52. Scott
53. Morgan
54. Sangamon
55. Christian
56. Macon
57. Moultrie
58. Douglas
59. Edgar
60. Clark
61. Coles
62. Cumberland
63. Shelby
64. Montgomery
65. Macoupin
66. Greene
67. Calhoun
68. Jersey
69. Madison
70. Bond
71. Fayette
72. Effingham
73. Jasper
74. Crawford
75. Lawrence
76. Richland
77. Clay
78. Marion
79. Clinton
80. St. Clair
81. Monroe
82. Randolph
83. Washington
84. Perry
85. Jefferson
86. Wayne
87. Edwards
88. Wabash
89. White
90. Hamilton
91. Franklin
92. Jackson
93. Williamson
94. Saline
95. Gallatin
96. Hardin
97. Pope
98. Johnson
99. Union
100. Alexander
101. Pulaski
102. Massac

I. & II. The three sections of Illinois, northern, central, and southern, and the ten stream systems of the state: I., the Galena District, II., the Rock River System, III., the Illinois River System, IV., the Lake Michigan drainage, V., the Mississippi River drainage, VI., the Kaskaskia River System, VII., the Wabash System, VIII., the Big Muddy River System, IX., the Saline River System, and X., the Cairo District.

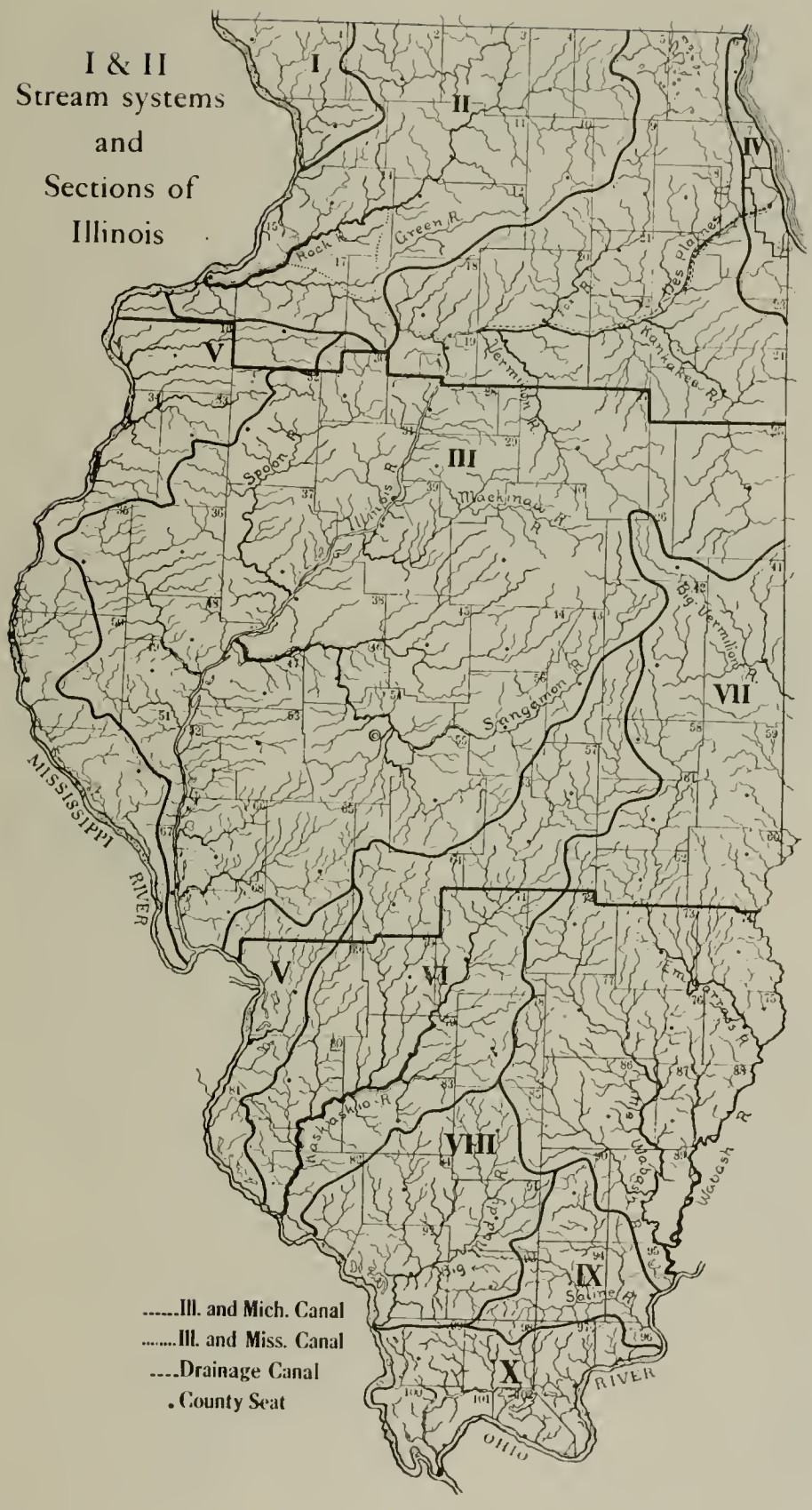
III. Glacial geology of Illinois.

IV. Localities from which collections were made.

V.—CII. Distribution of species.

CIII. Northern species (●) and southern species (▲) in Illinois.

V. Lepisosteus osseus
VI. L. platostomus
VII. Amia calva
VIII. Dorosoma cepedianum
IX. Ictiobus cyprinella
X. I. urus
XI. I. bubalus
XII. Carpiodes carpio
XIII. C. difformis
XIV. C. velifer
XV. C. thompsoni
XVI. Erimyzon sucetta oblongus
XVII. Minytrema melanops
XVIII. Catostomus commersonii
XIX. C. nigricans
XX. Moxostoma anisurum
XXI. M. aureolum
XXII. M. breviceps
XXIII. Campostoma anomalum
XXIV. Chrosomus erythrogaster
XXV. Hybognathus nuchalis
XXVI. H. nubila
XXVII. Pimephales promelas
XXVIII. P. notatus
XXIX. Semotilus atromaculatus
XXX. Opsopœodus emiliæ
XXXI. Abramis crysoleucas
XXXII. Cliola vigilax
XXXIII. Notropis cayuga
XXXIV. N. heterodon
XXXV. N. blennius
XXXVI. N. gilberti
XXXVII. N. illecebrosus
XXXVIII. N. hudsonius
XXXIX. N. lutrensis
XL. N. whipplii
XLI. N. cornutus
XLII. N. jejunus
XLIII. N. atherinoides
XLIV. N. rubrifrons
XLV. N. umbratilis atripes
XLVI. Ericymba buccata
XLVII. Phenacobius mirabilis
XLVIII. Hybopsis dissimilis
XLIX. H. amblops
L. H. storerianus
LI. H. kentuckiensis
LII. Ictalurus punctatus
LIII. Ameiurus natalis
LIV. A. nebulosus
LV. A. melas
LVI. Leptops olivaris
LVII. Noturus flavus
LVIII. Schilbeodes gyrinus
LIX. S. miurus
LX. Umbra limi
LXI. Esox vermiculatus
LXII. E. lucius
LXIII. Fundulus diaphanus menona
LXIV. F. dispar
LXV. F. notatus
LXVI. Gambusia affinis
LXVII. Percopsis guttatus
LXVIII. Labidesthes sicculus
LXIX. Aphredoderus sayanus
LXX. Pomoxis annularis
LXXI. P. sparoides
LXXII. Centrarchus macropterus
LXXIII. Ambloplites rupestris
LXXIV. Chænobryttus gulosus
LXXV. Lepomis miniatus
LXXVI. L. megalotis
LXXVII. L. humilis
LXXVIII. L. pallidus
LXXIX. Eupomotis gibbosus
LXXX. Micropterus dolomieu
LXXXI. M. salmoides
LXXXII. Stizostedion vitreum
LXXXIII. S. canadense griseum
LXXXIV. Perca flavescens
LXXXV. Percina caprodes
LXXXVI. Hadropterus phoxocephalus
LXXXVII. H. aspro
LXXXVIII. Cottogaster shumardi
LXXXIX. Diplesion blennioides
XC. Boleosoma nigrum
XCI. B. camurum
XCII. Ammocrypta pellucida
XCIII. Etheostoma zonale
XCIV. E. jessiæ
XCV. E. cœruleum
XCVI. E. squamiceps
XCVII. E. flabellare
XCVIII. Boleichthys fusiformis
XCIX. Microperca punctulata
C. Roccus chrysops
CI. Morone interrupta
CII. Aplodinotus grunniens


I & II
Stream systems
and
Sections of
Illinois
I
II
III
IV
V
VI
VII
VIII
IX
X
Rock R.
Green R.
Illinois R.
Spoon R.
Vermilion R.
Kankakee R.
Mackinaw R.
Big Vermilion R.
Sangamon R.
Embarras R.
Wabash R.
Kaskaskia R.
Saline R.
MISSISIPPI RIVER
OHIO RIVER
.....Ill. and Mich. Canal
.....Ill. and Miss. Canal
----Drainage Canal
. County Seat


V
Distribution
of
Lepisosteus
osseus
Rock R.
Green R.
Des Plaines R.
Kankakee R.
Vermilion R.
Spoon R.
Illinois R.
Mackinaw R.
Big Vermilion R.
Sangamon R.
MISSISSIPPI RIVER
Embarrass R.
Wabash R.
Little Wabash R.
Kaskaskia R.
Big Muddy R.
Saline R.
OHIO RIVER
.....Ill. and Mich. Canal
.....Ill. and Miss. Canal
.....Drainage Canal
. County Seat

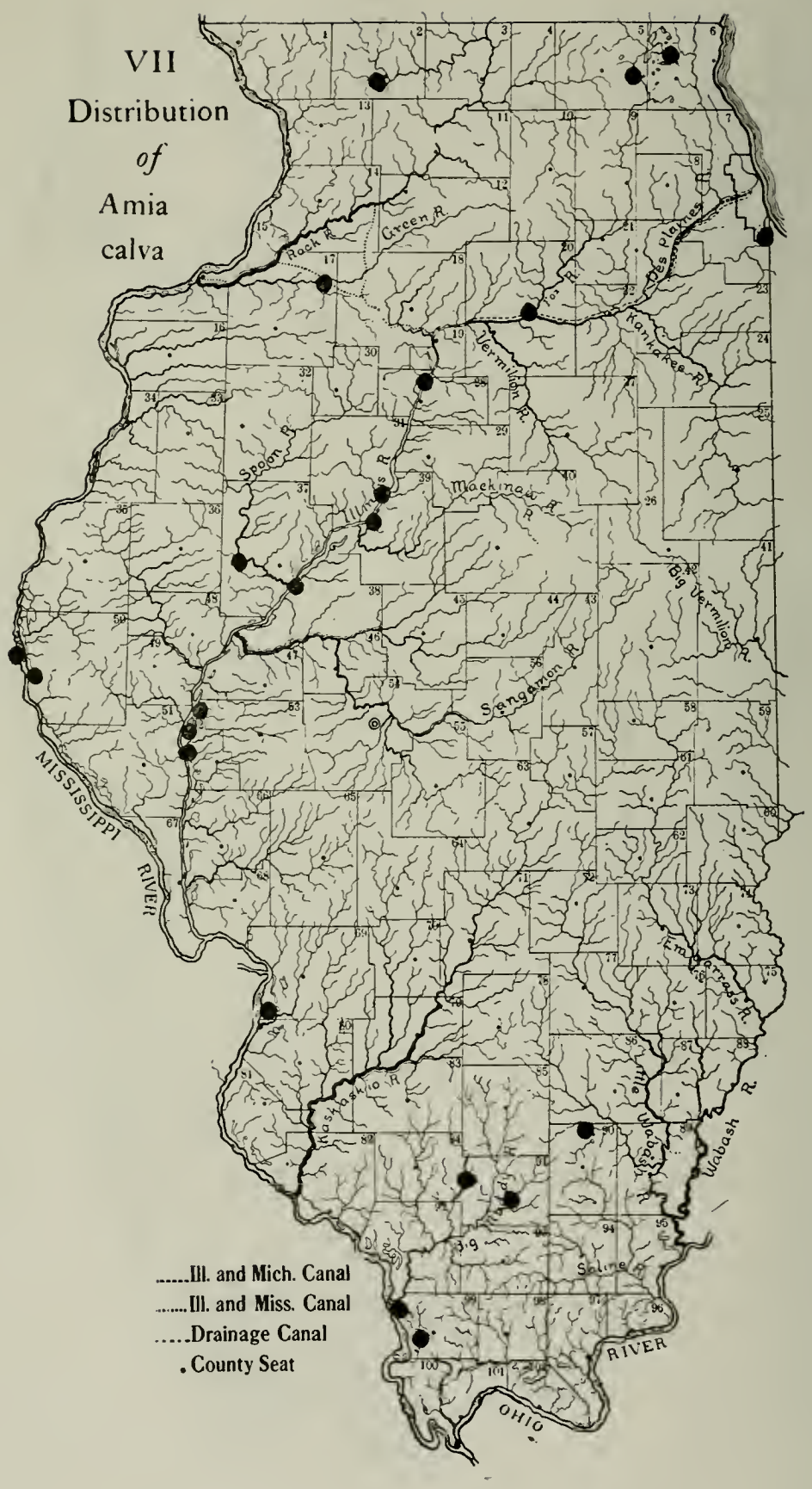
VI

Distribution

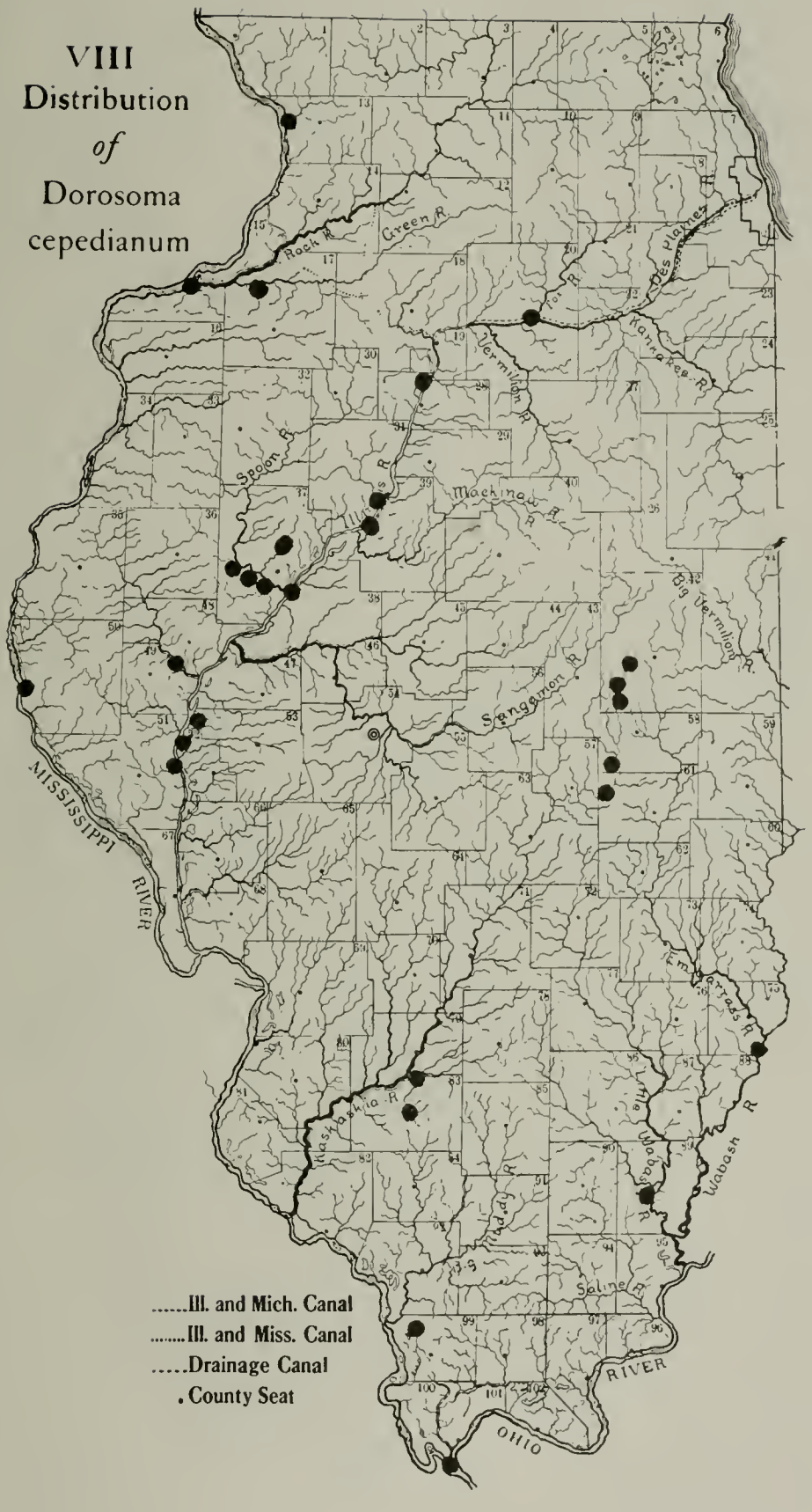
of

Lepisosteus

platostomus

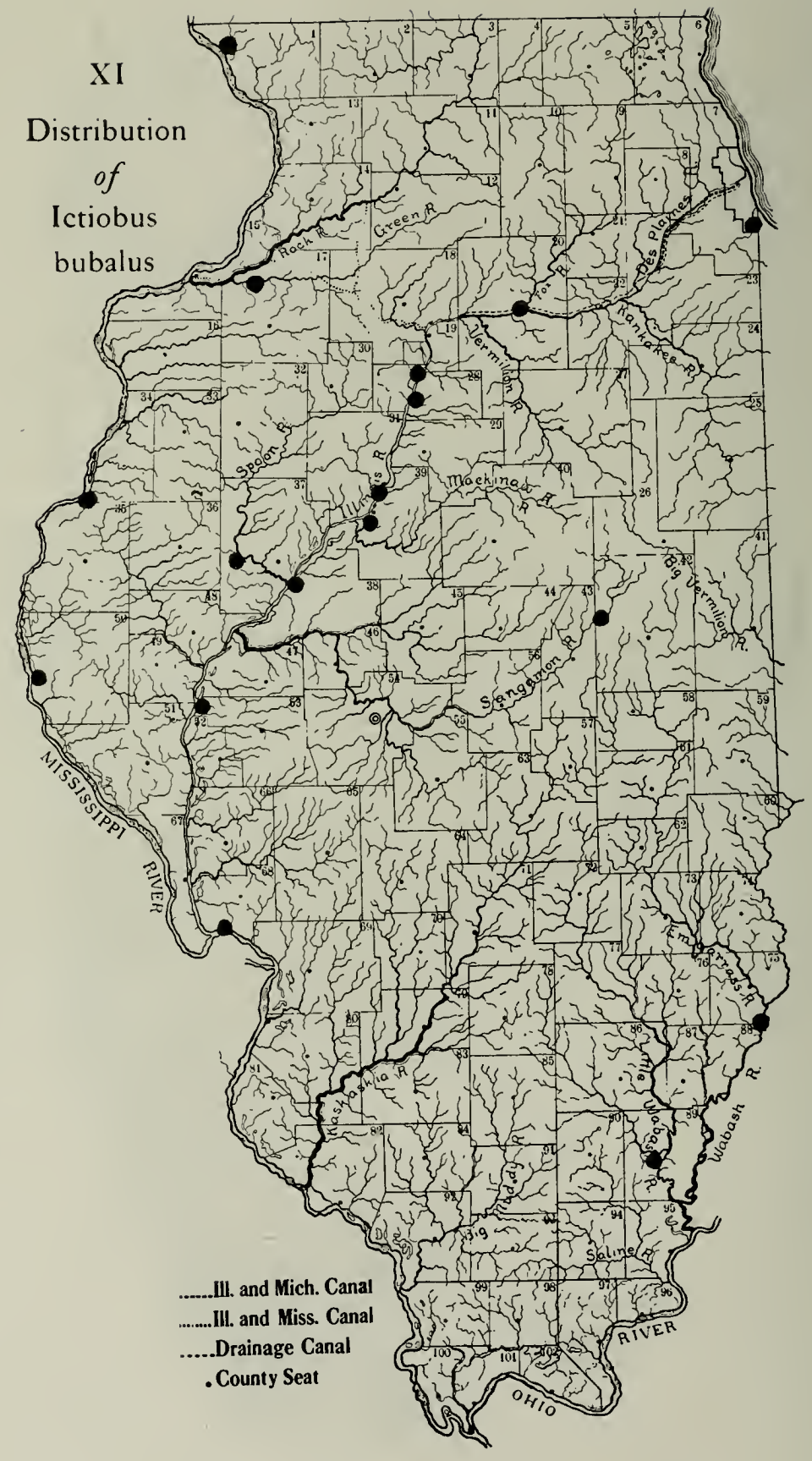

VII
Distribution
of
Amia
calva
Rock R.
Green R.
Des plaines R.
Fox R.
Kankakee R.
Vermilion R.
Spoon R.
Illinois R.
Mackinaw R.
Big Vermilion R.
Sangamon R.
MISSISSIPPI RIVER
Embarras R.
Little Wabash R.
Wabash R.
Saline R.
Big Muddy R.
RIVER
OHIO
.....Ill. and Mich. Canal
.....Ill. and Miss. Canal
.....Drainage Canal
. County Seat

VIII
Distribution
of
Dorosoma
cepedianum



XI

Distribution
of
Ictiobus
bubalus



XII

Distribution

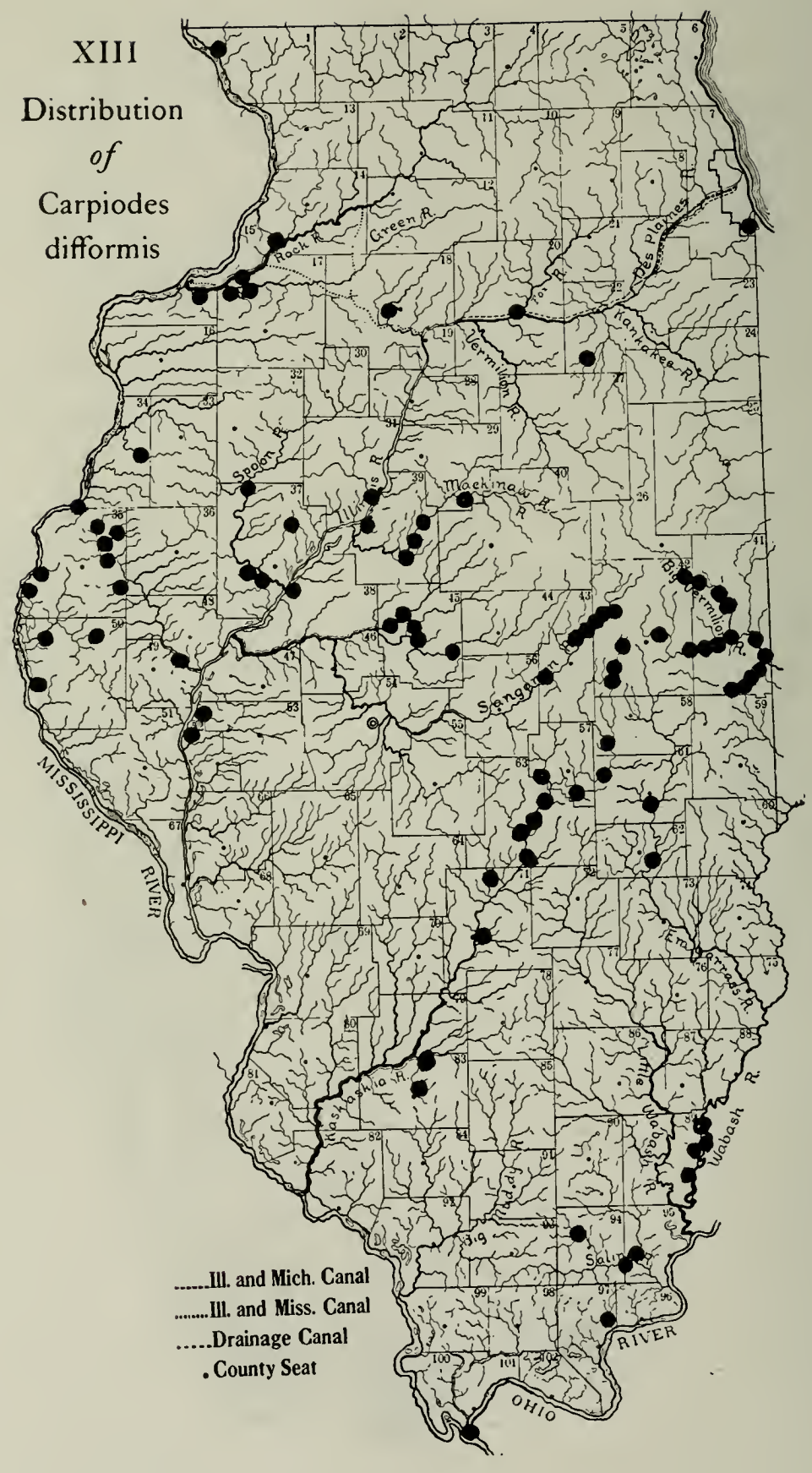
of

Carpiodes

carpio

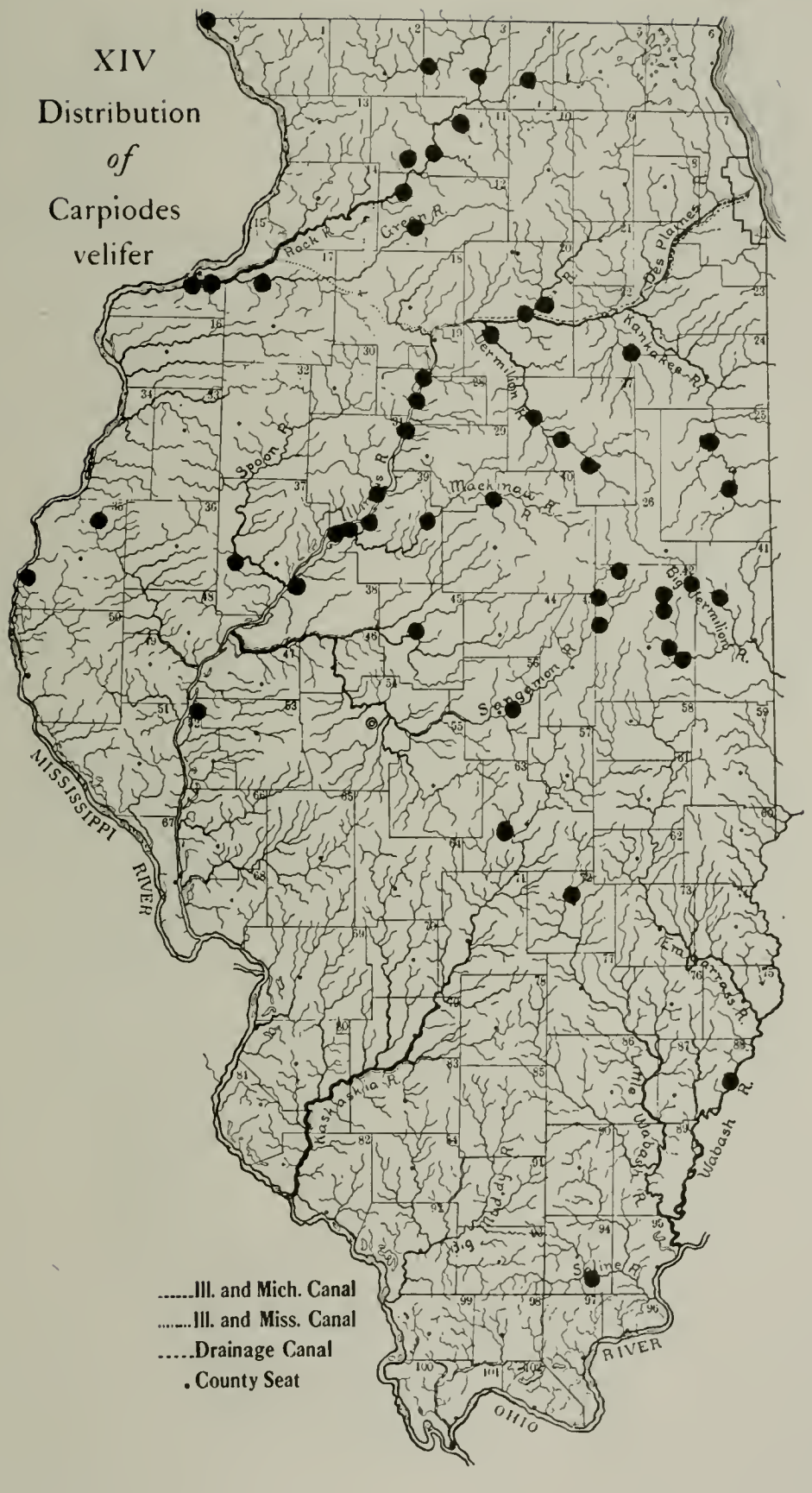
XIII

Distribution
of
Carpiodes
difformis

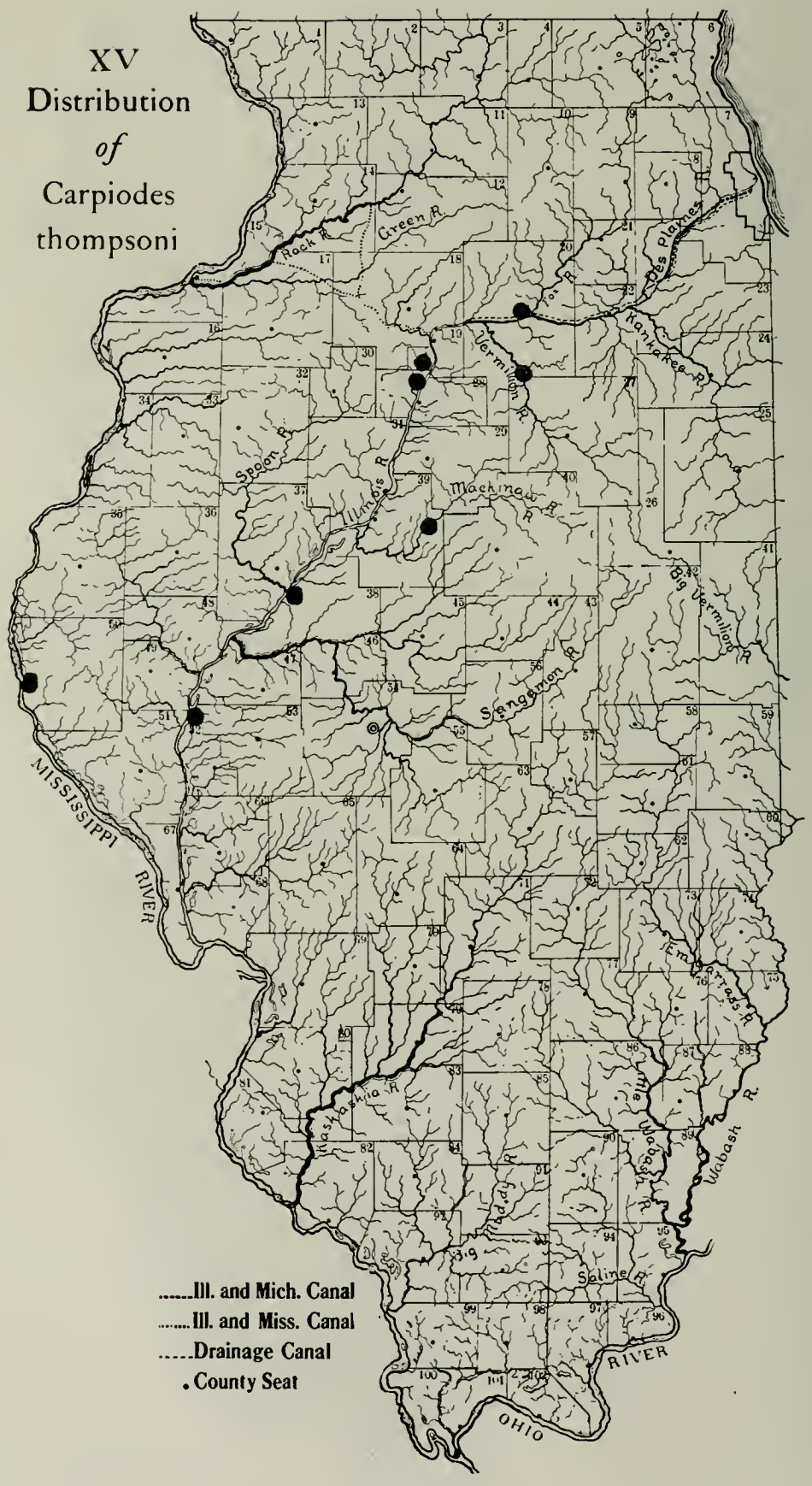


XIV

Distribution *of* Carpiodes velifer



XV
Distribution
of
Carpiodes
thompsoni



XVI

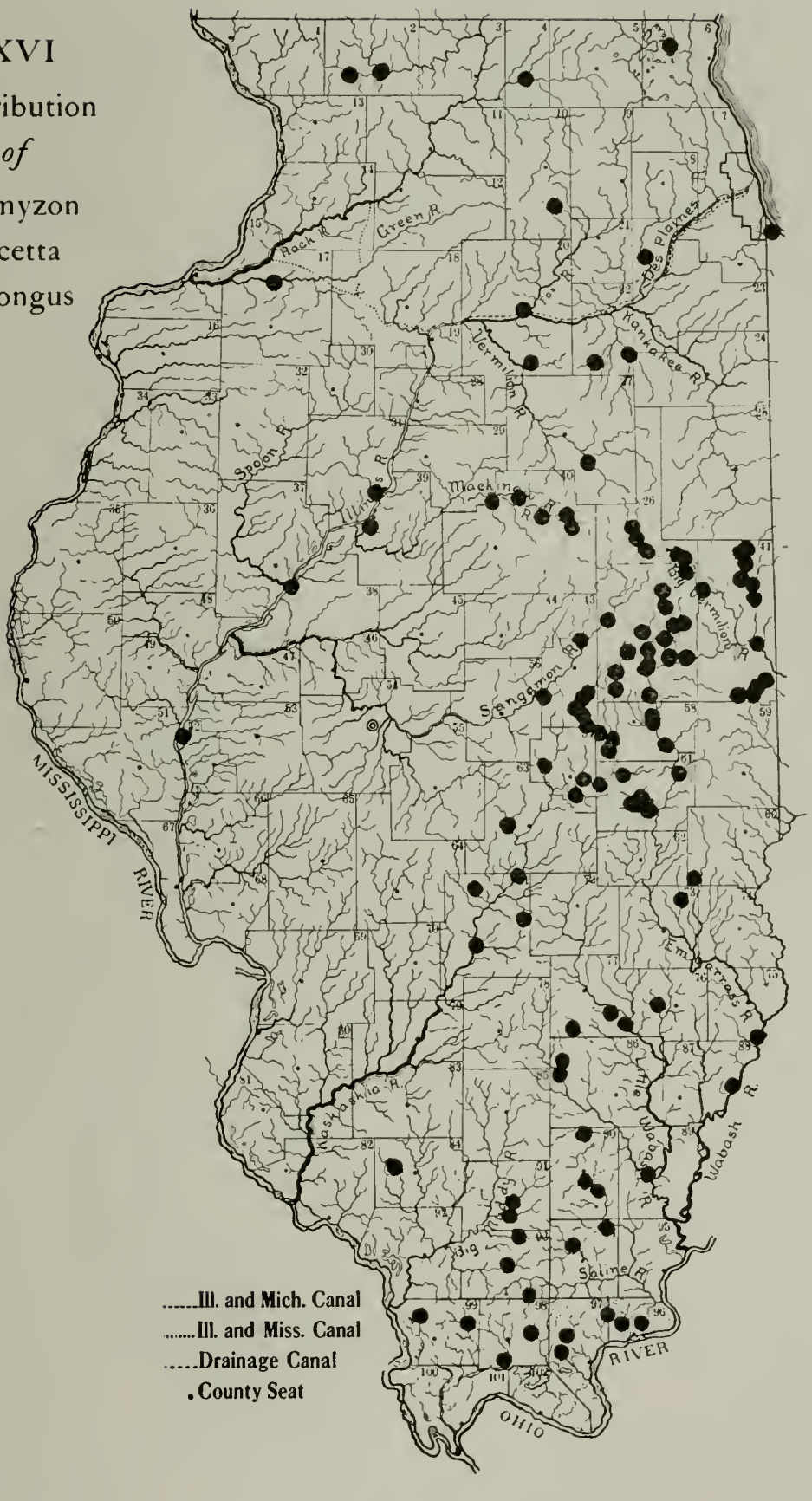
Distribution

of

Erimyzon

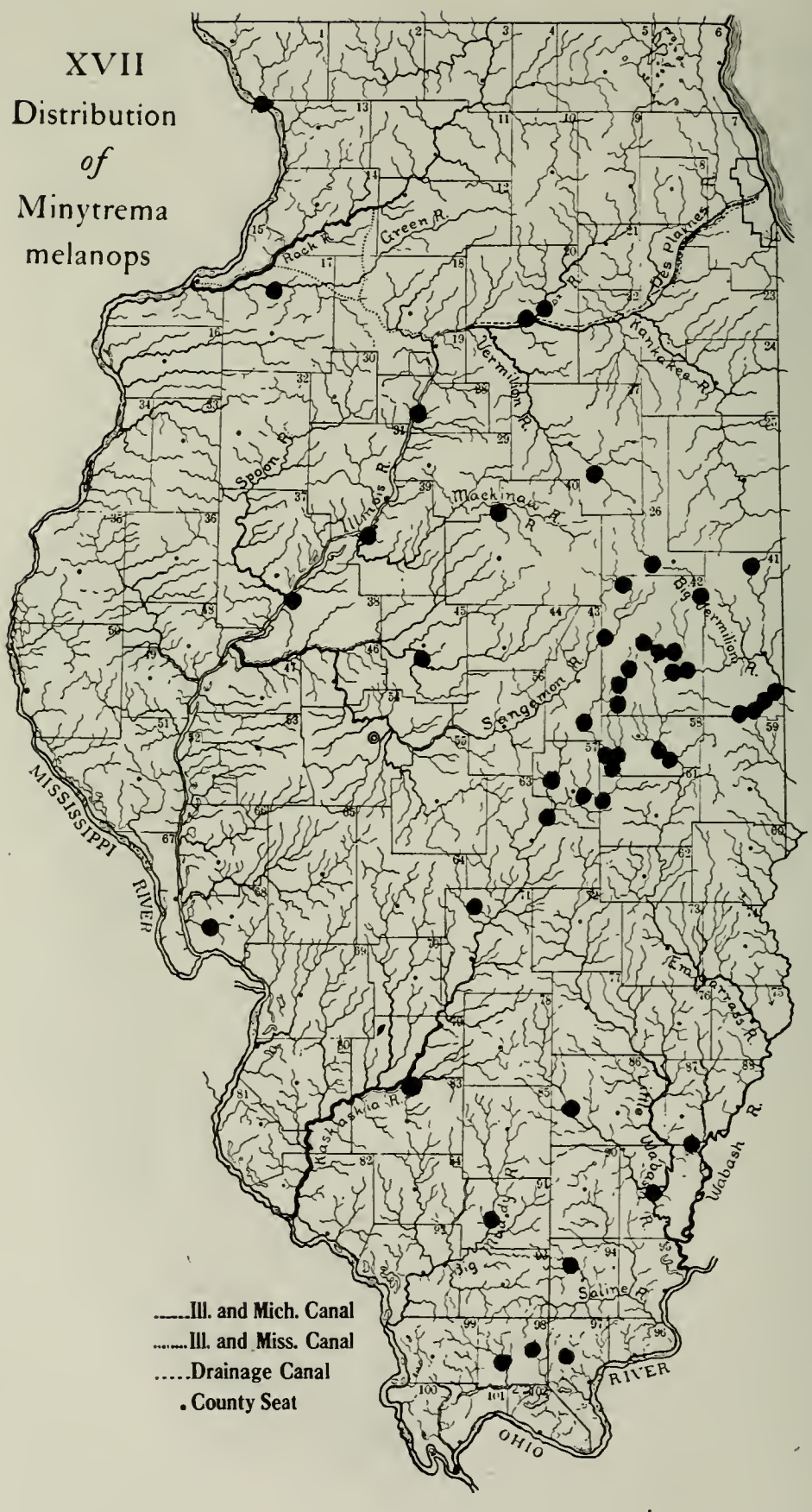
sucetta

oblongus

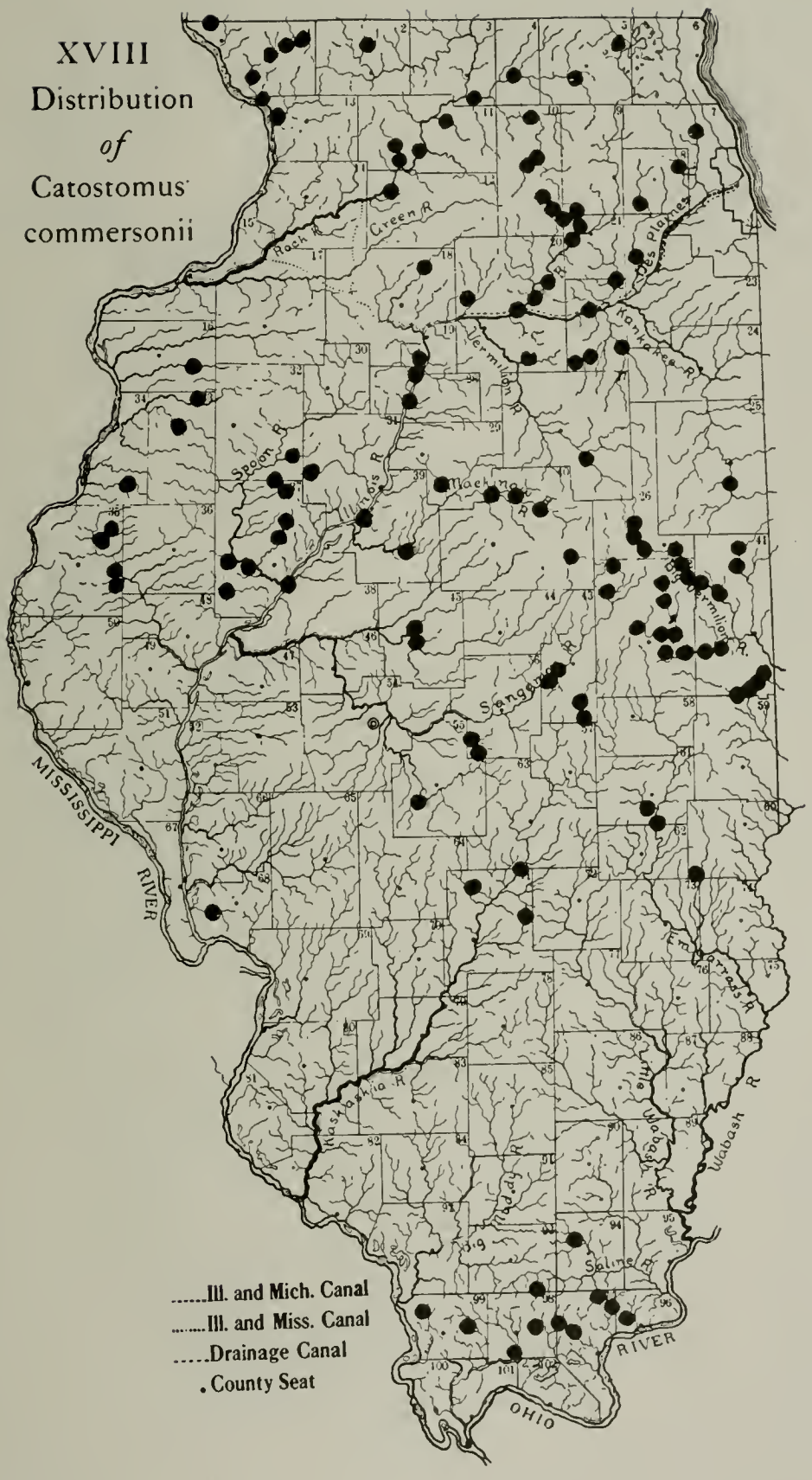


XVII

Distribution *of* Minytrema melanops



XVIII
Distribution
of
Catostomus
commersonii



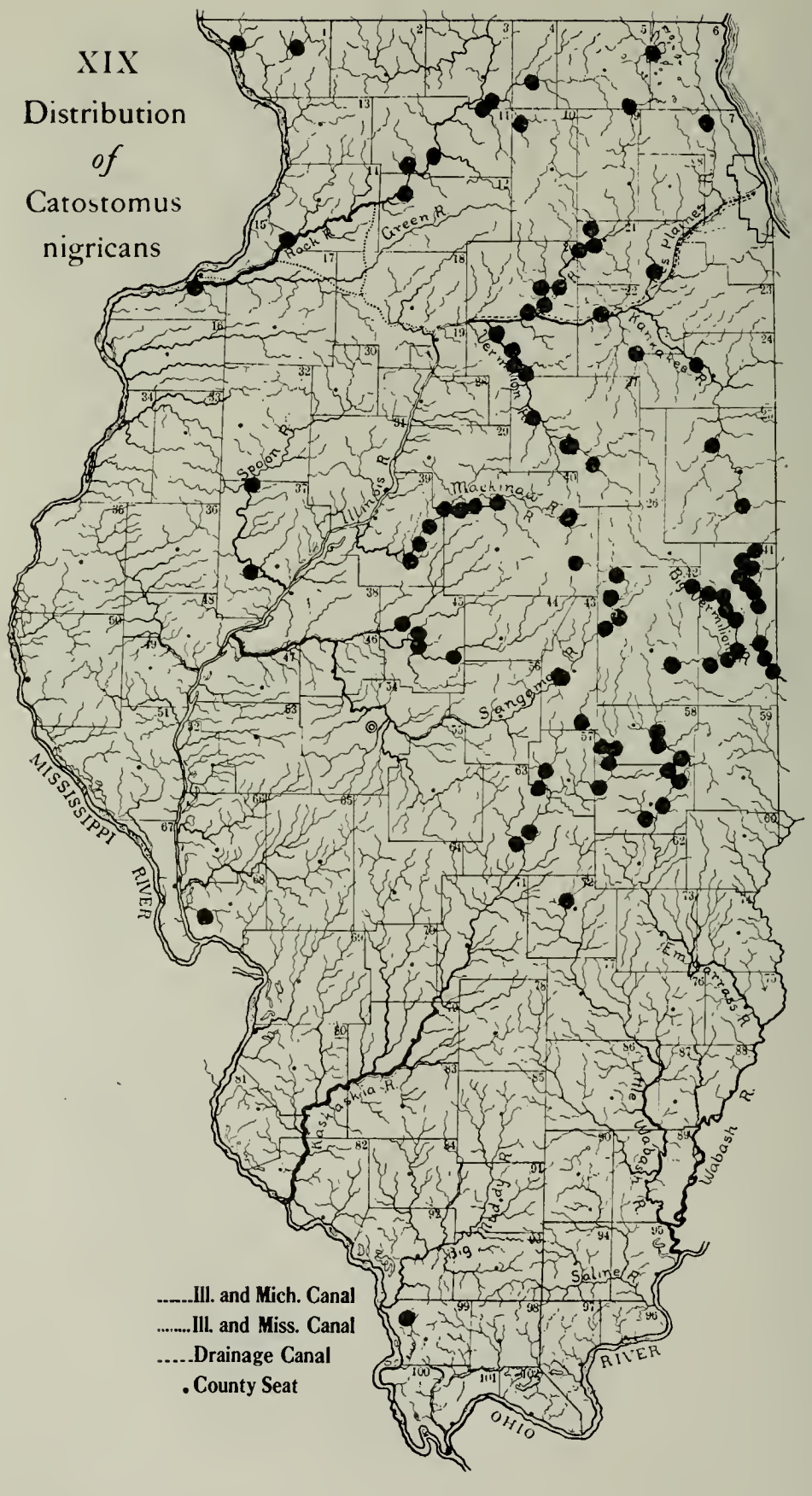
XIX

Distribution

of

Catostomus

nigricans



XX

Distribution

of

Moxostoma

anisurum

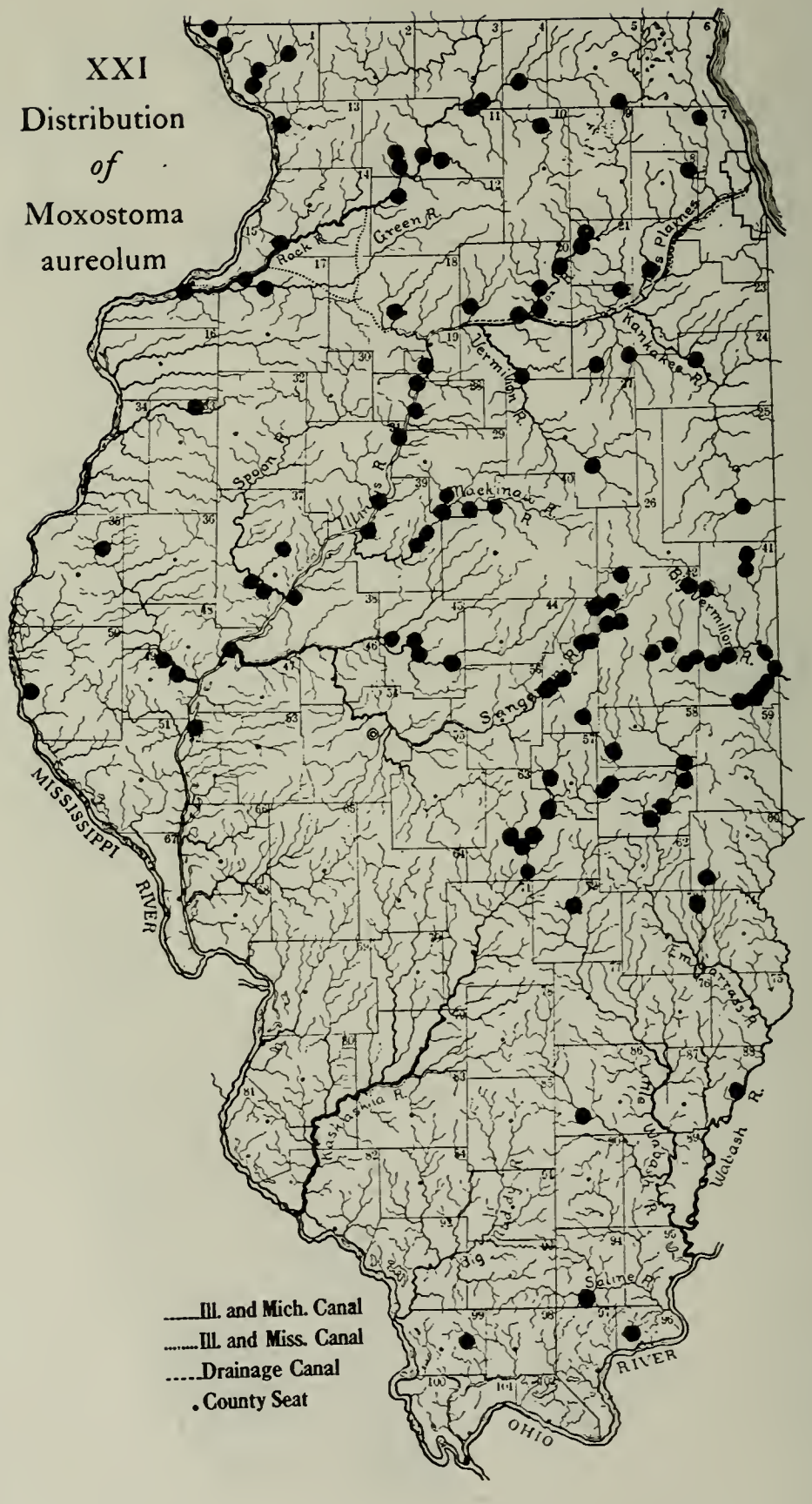
XXI

Distribution

of

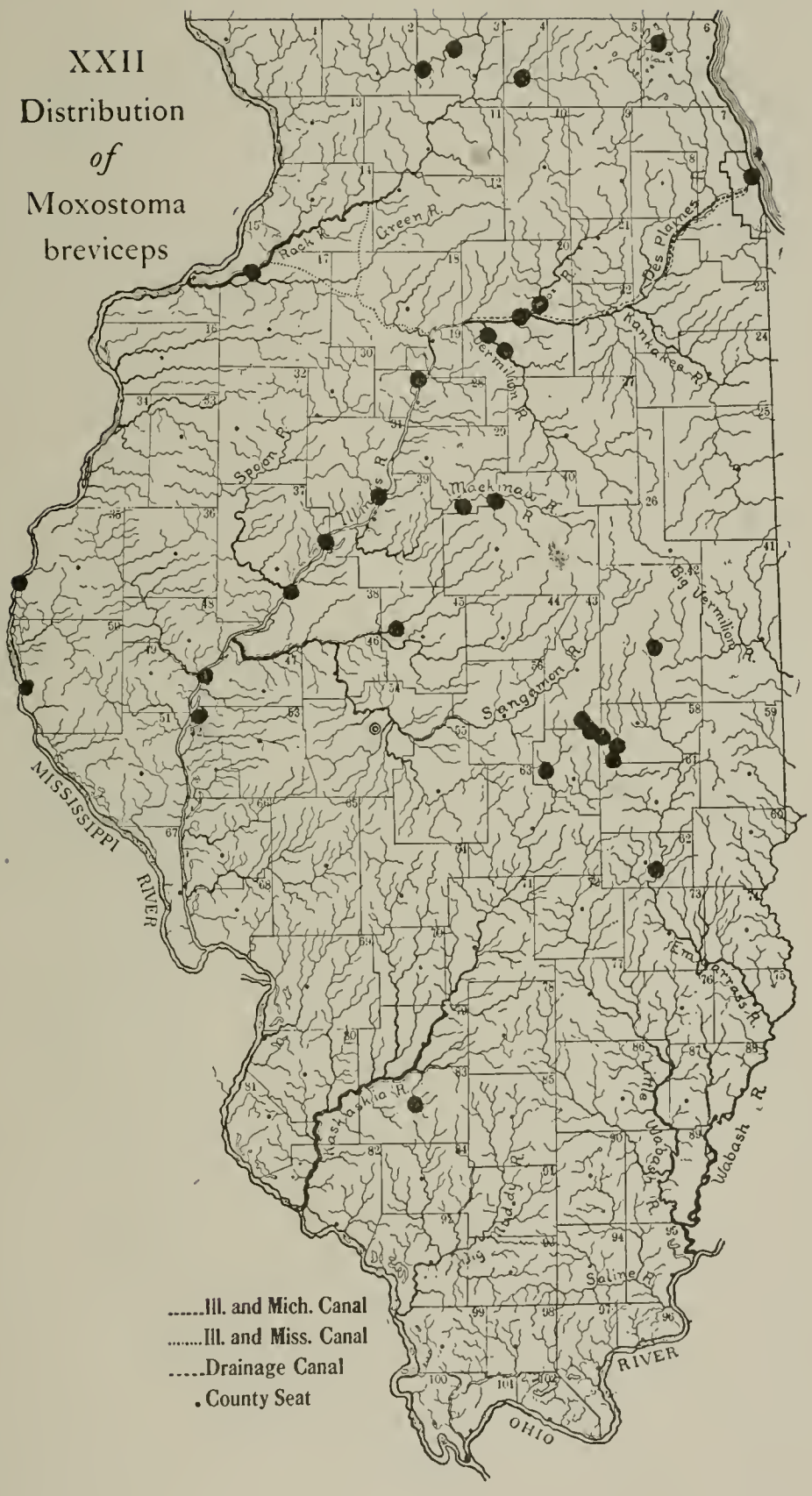
Moxostoma

aureolum

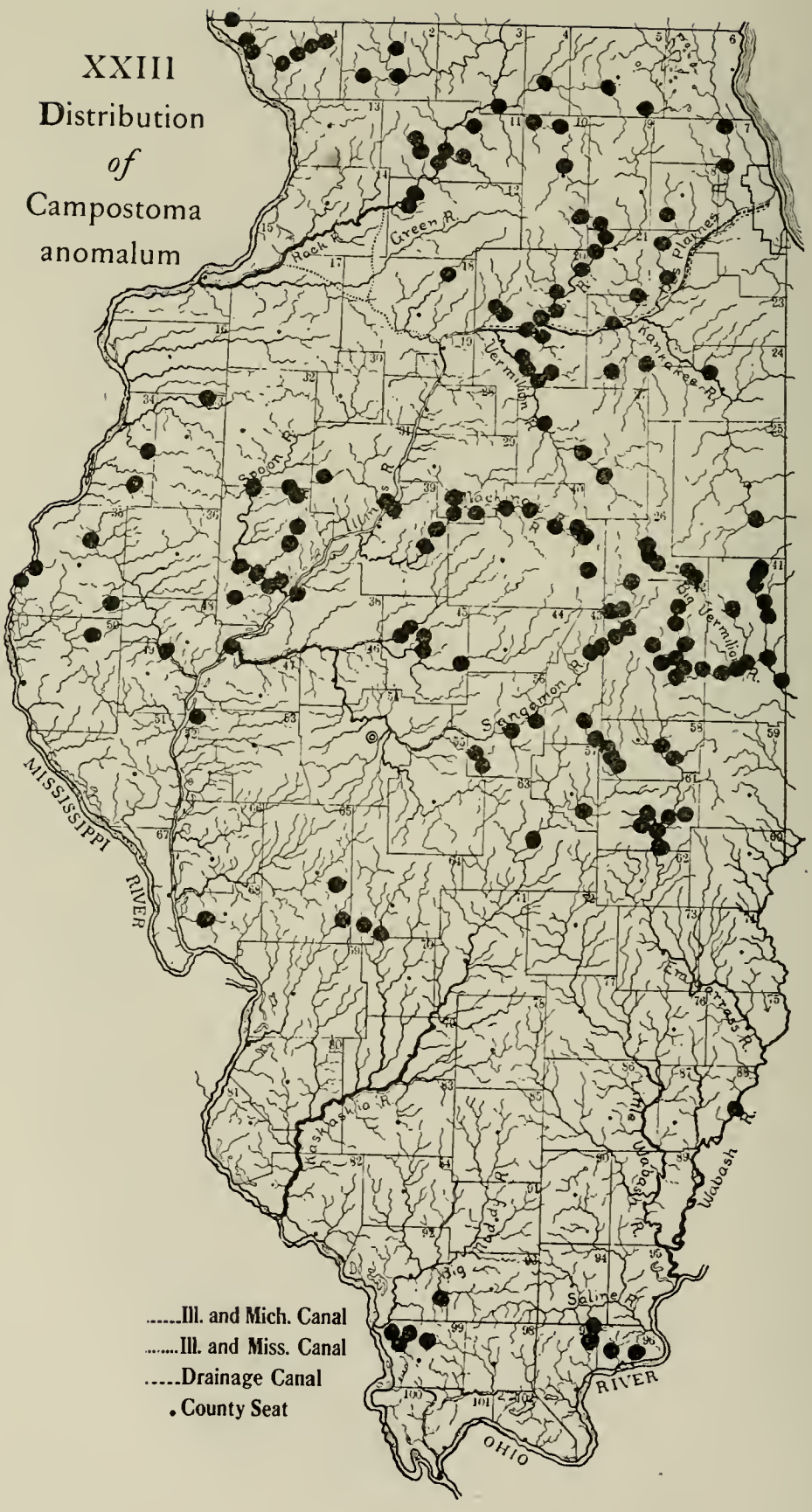


XXII

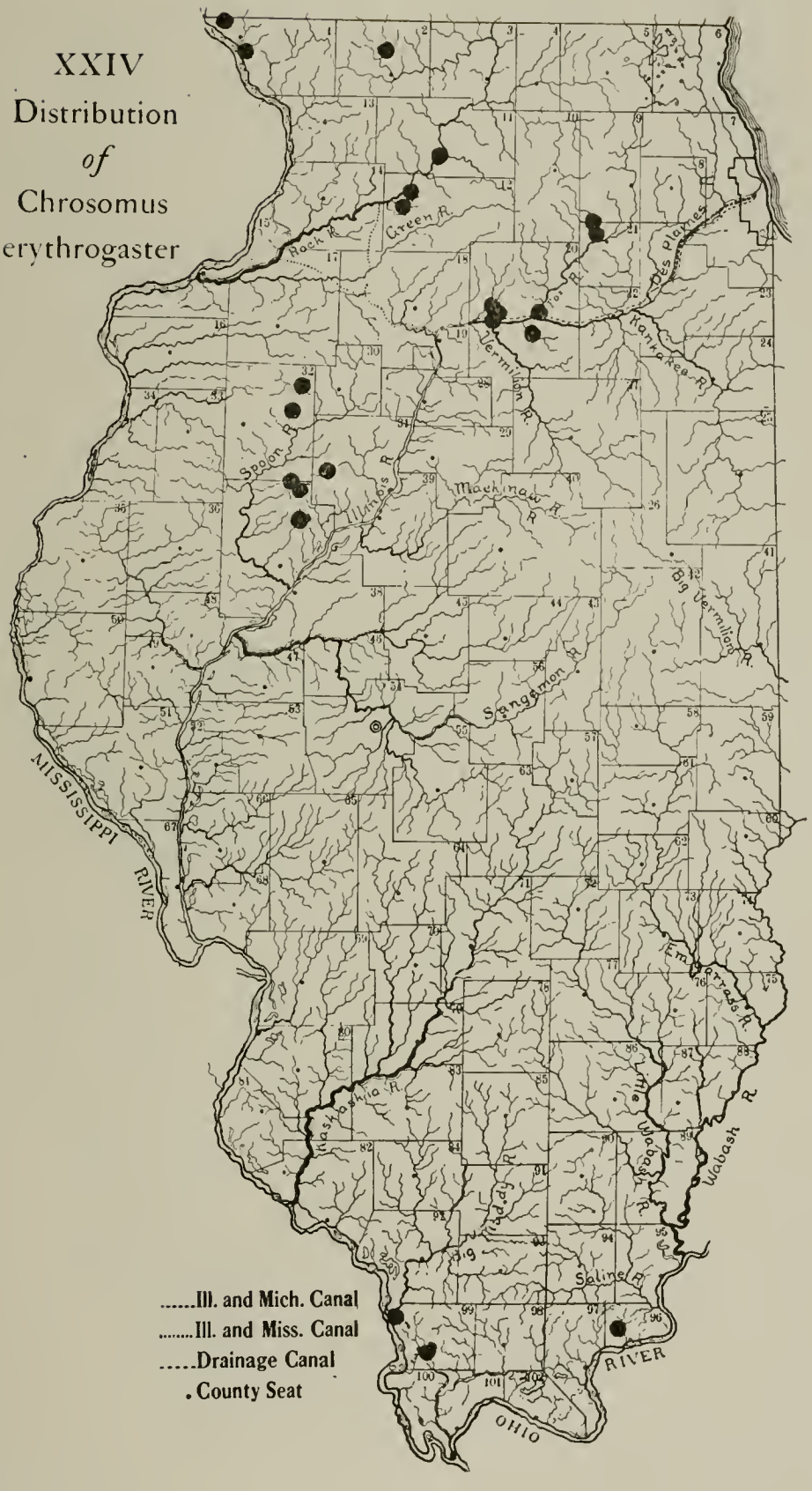
Distribution *of* Moxostoma breviceps



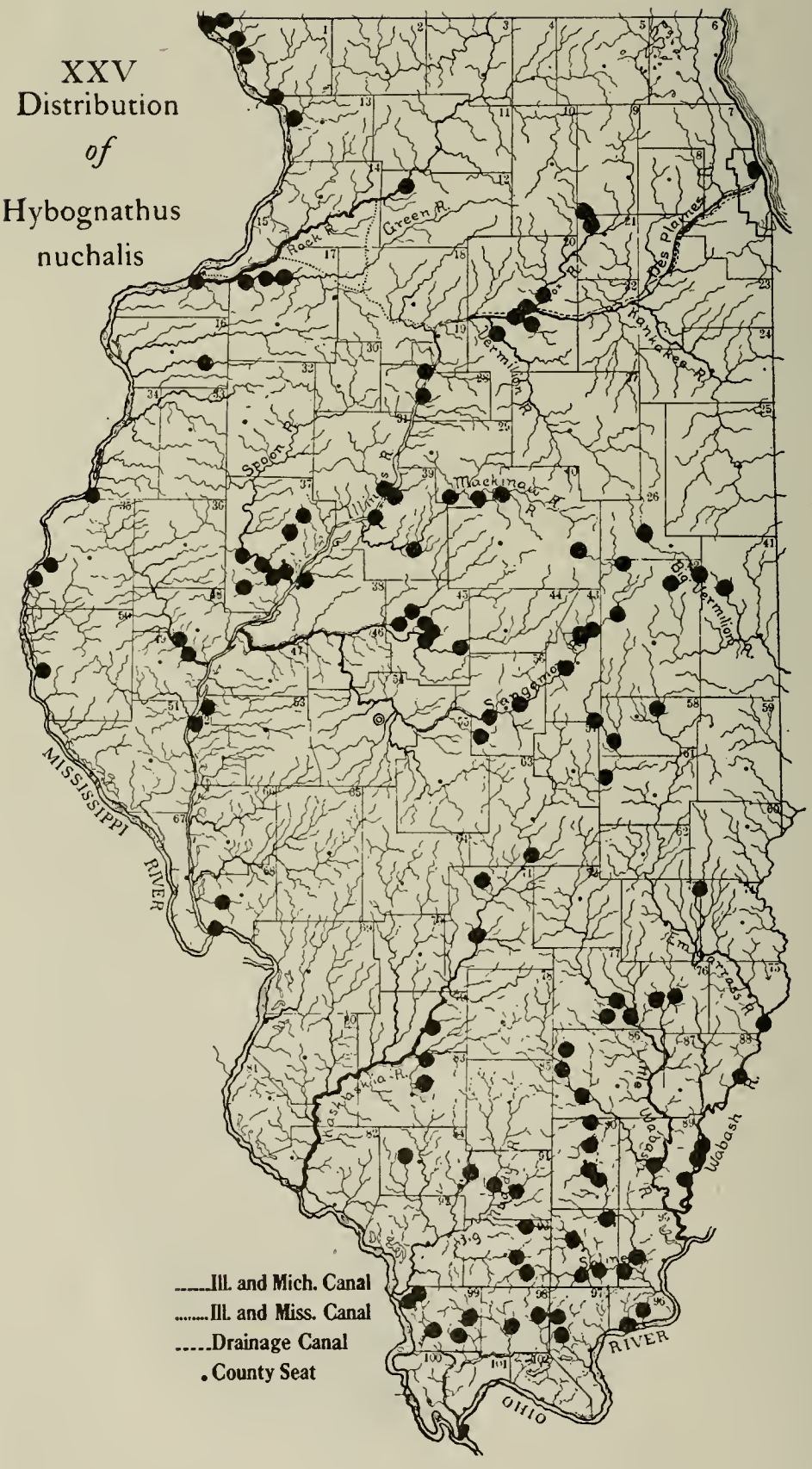
XXIII
Distribution
of
Campostoma
anomalum



XXIV
Distribution
of
Chrosomus
erythrogaster



XXV
Distribution
of
Hybognathus
nuchalis



XXVI

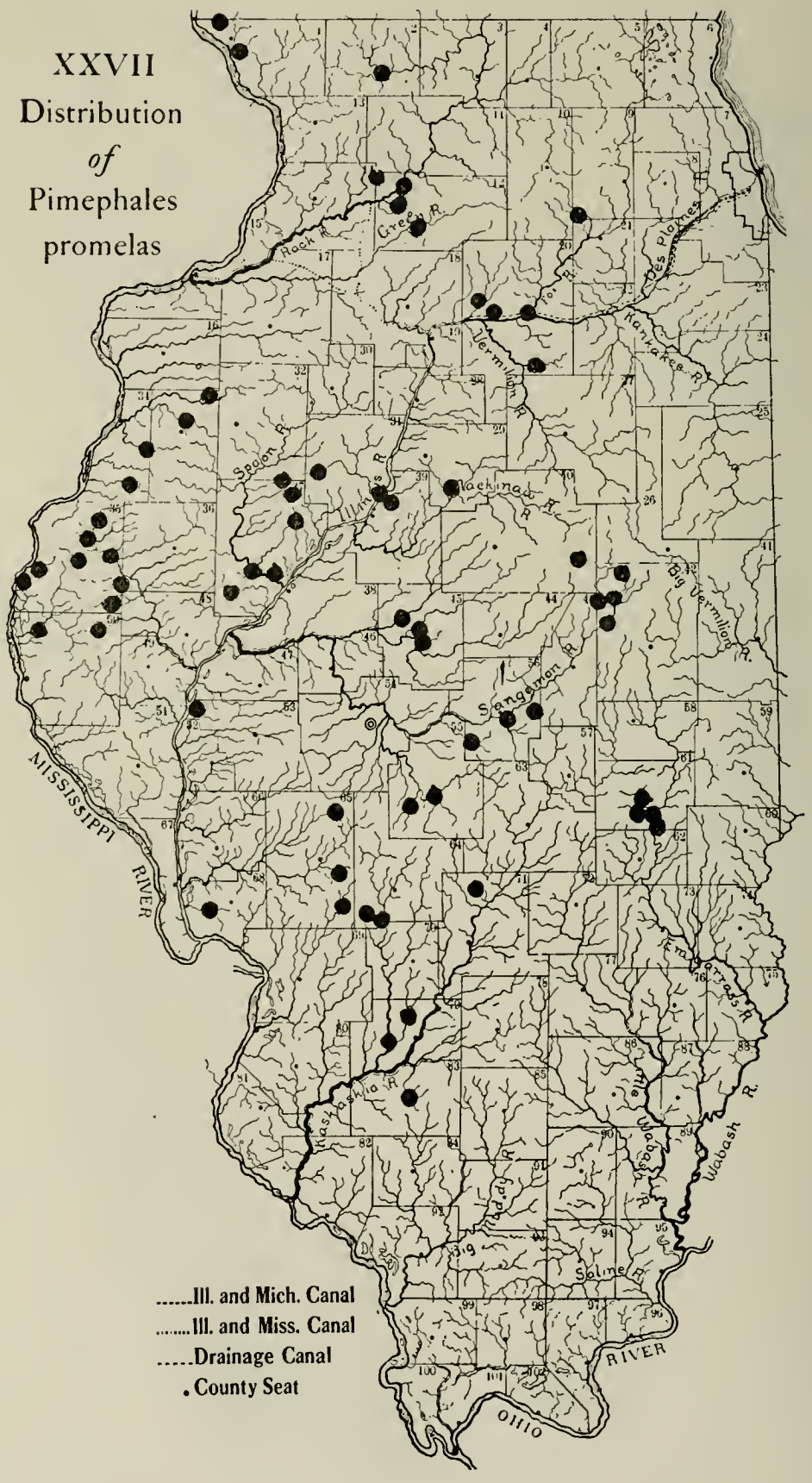
Distribution

of

Hybognathus

nubila

XXVII
Distribution
of
Pimephales
promelas



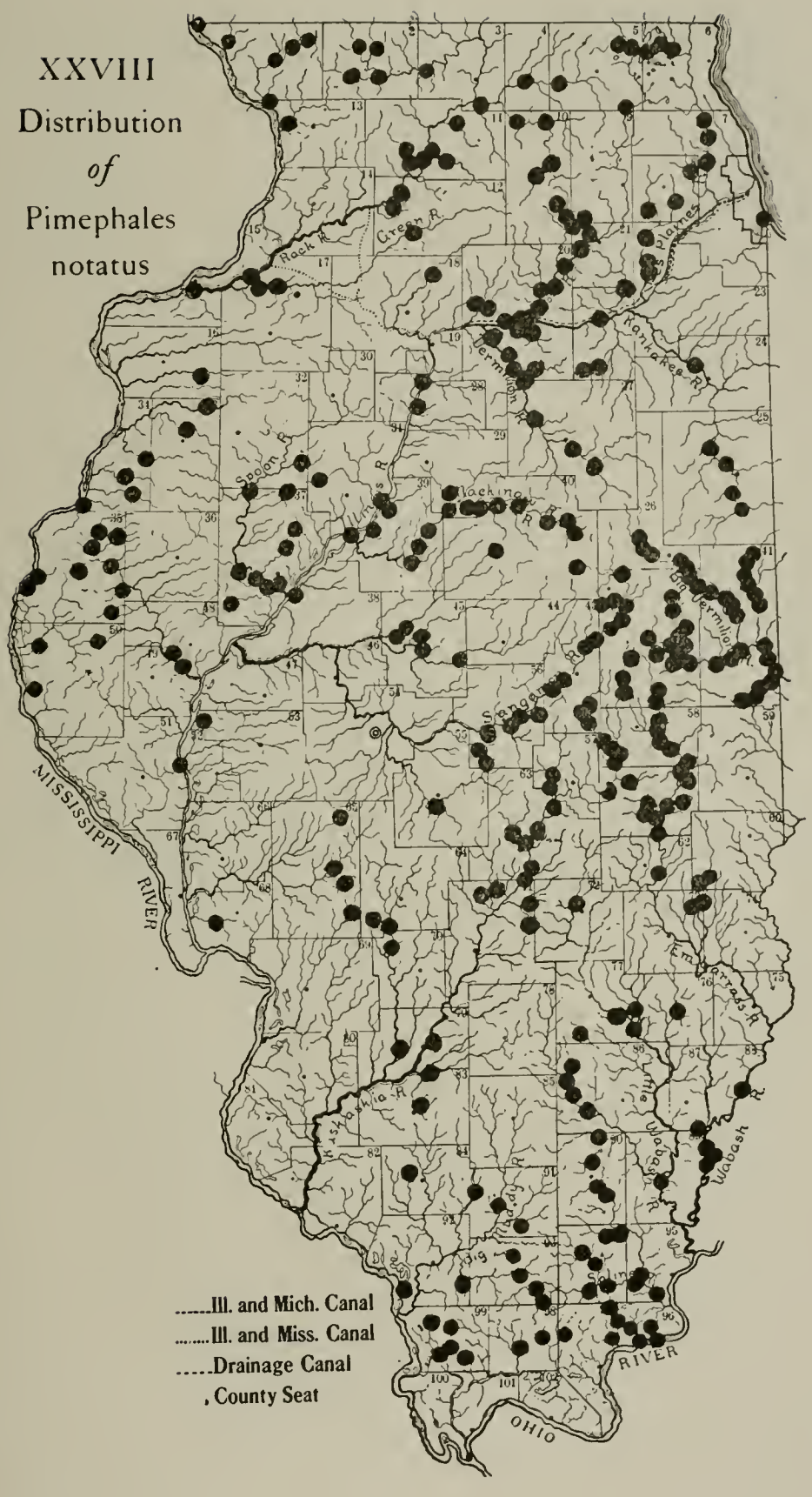
XXVIII

Distribution

of

Pimephales

notatus



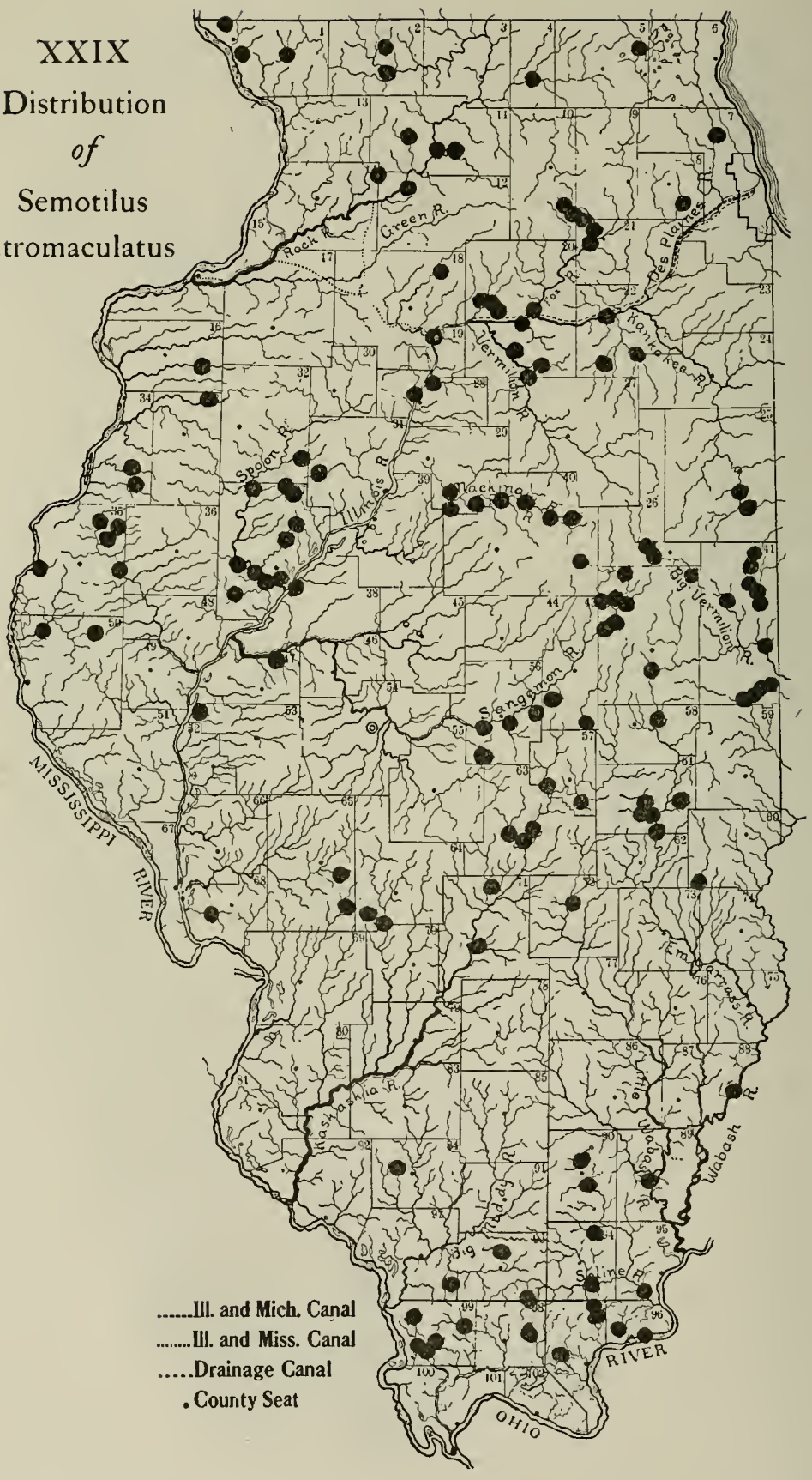
XXIX

Distribution

of

Semotilus

atromaculatus



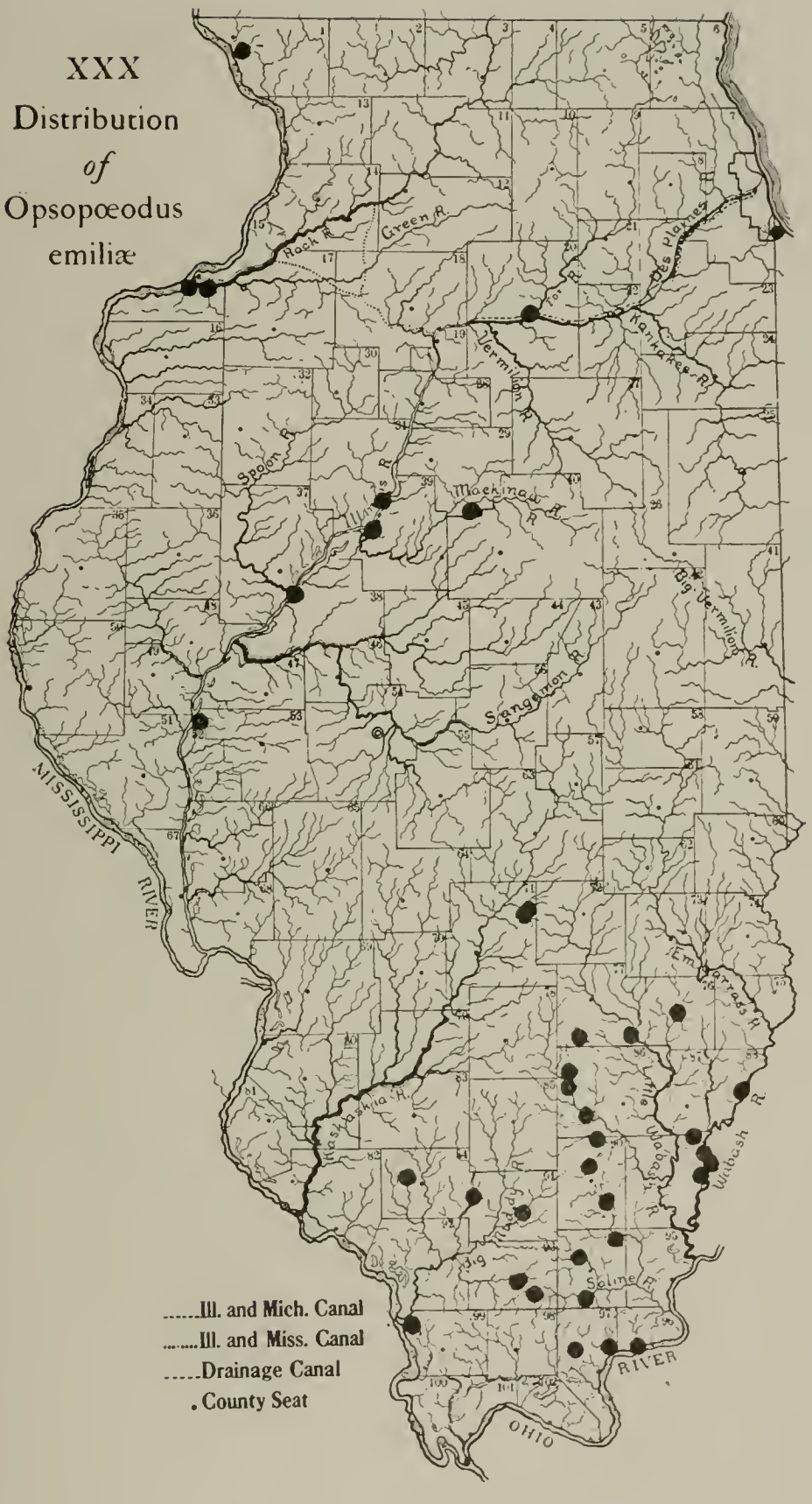
XXX

Distribution

of

Opsopœodus

emiliæ



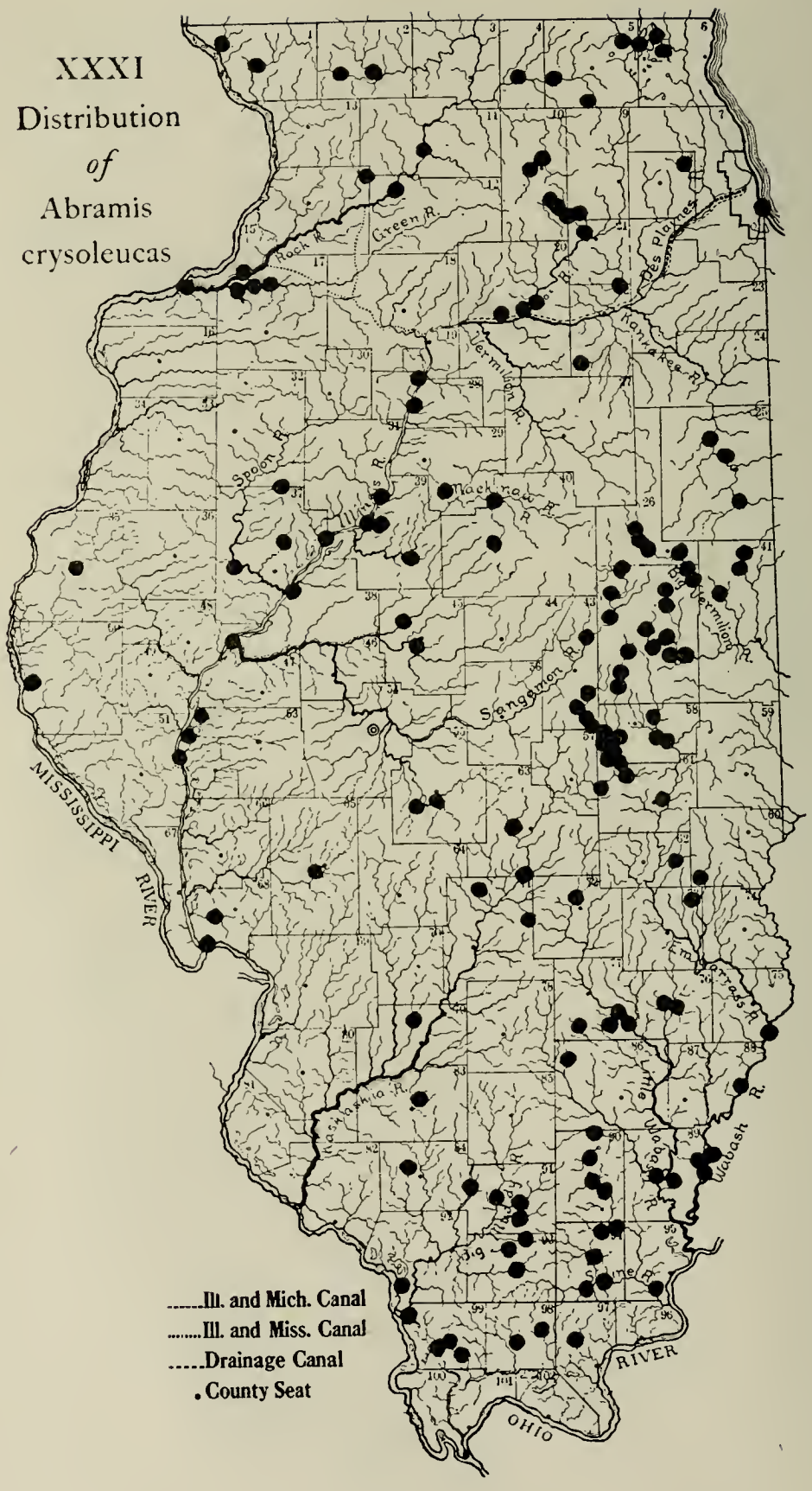
XXXI

Distribution

of

Abramis

crysoleucas



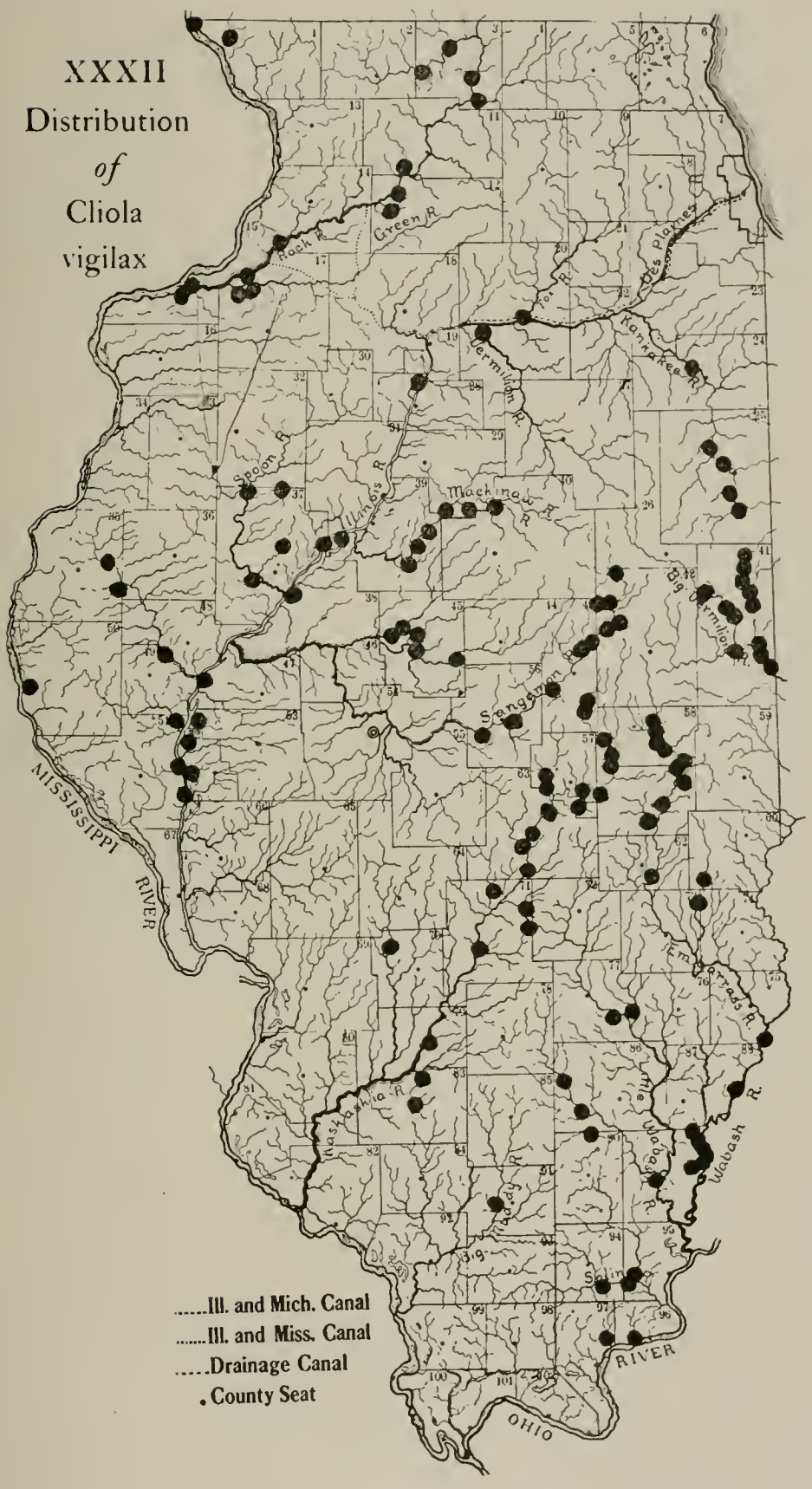
XXXII

Distribution

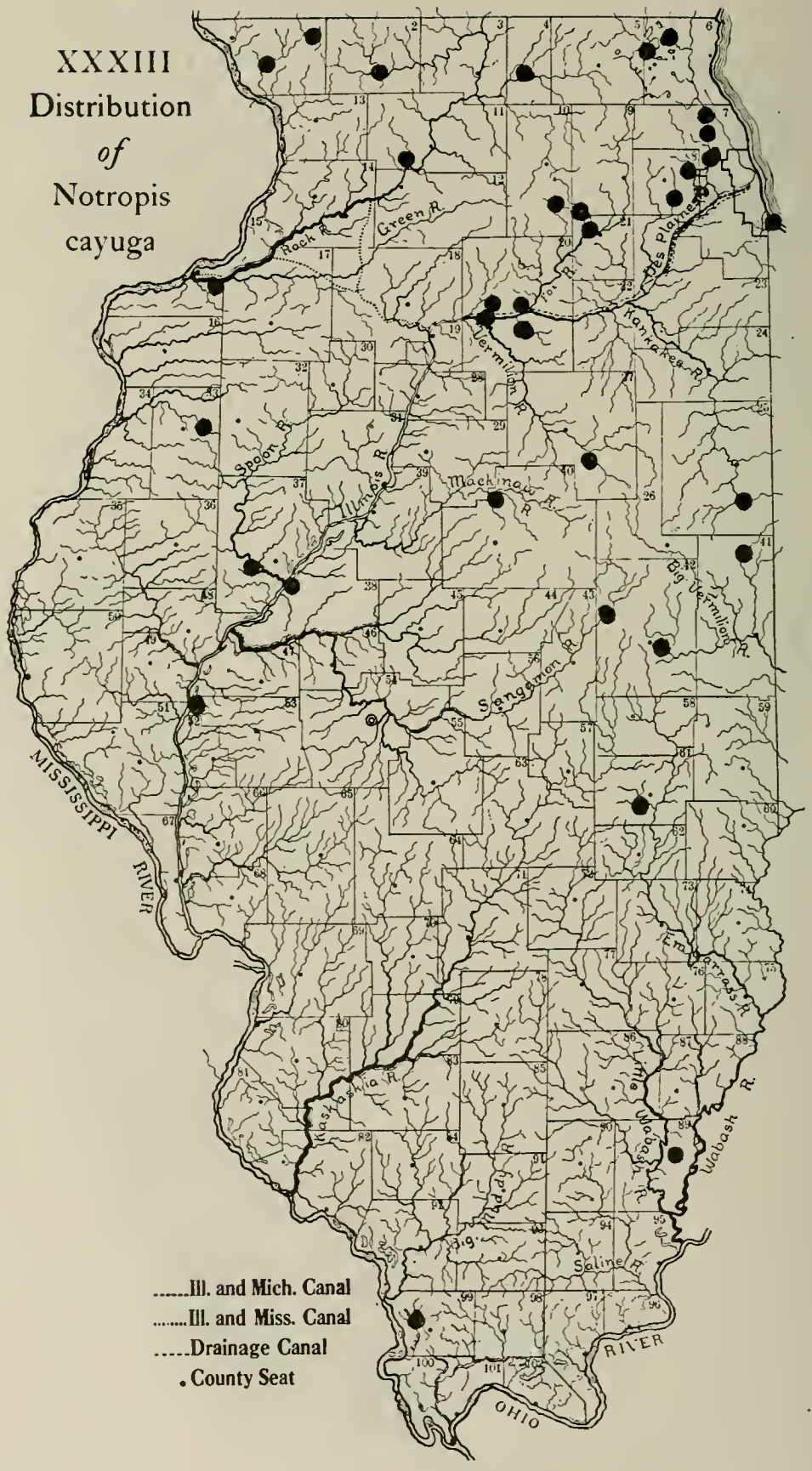
of

Cliola

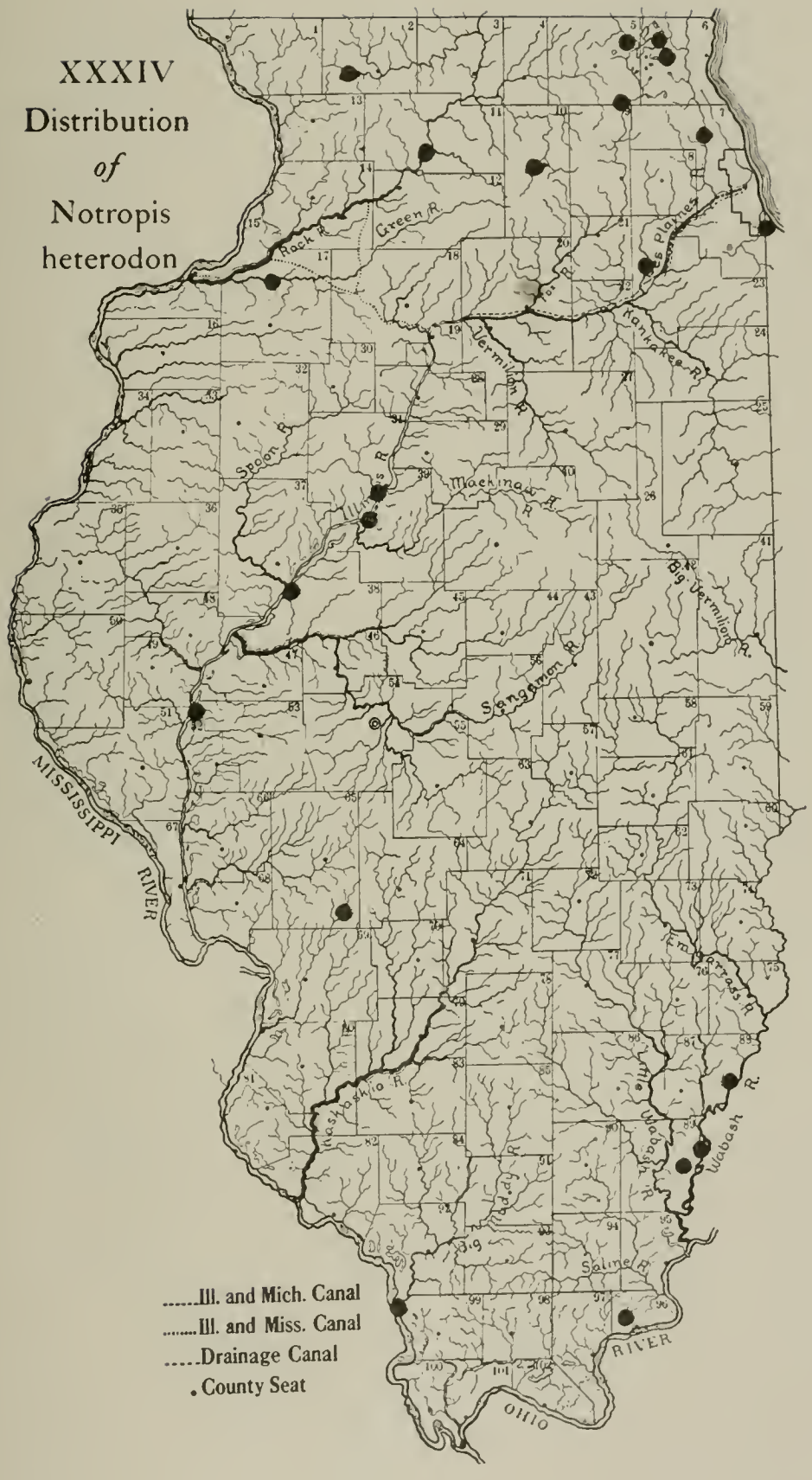
vigilax

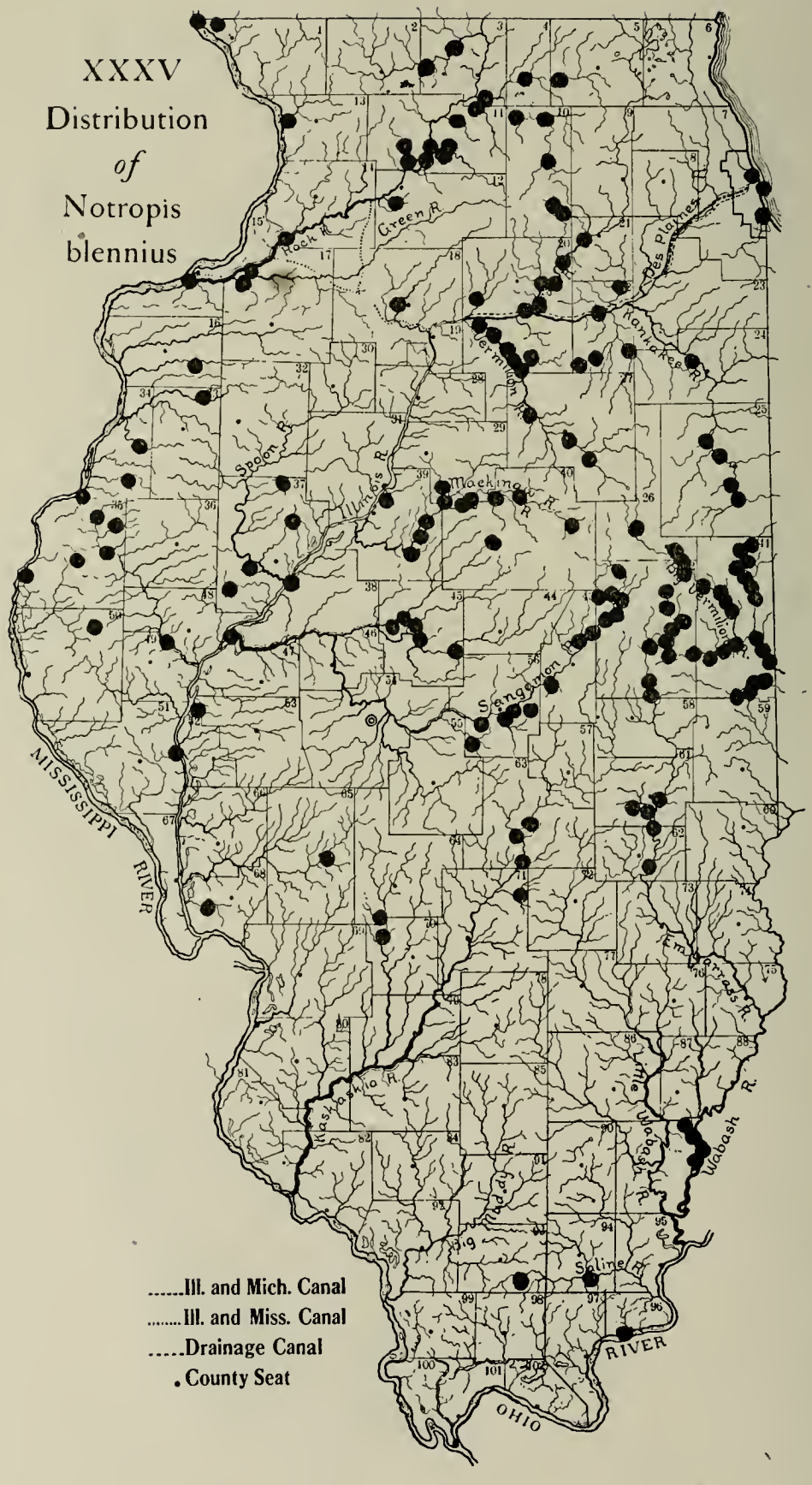


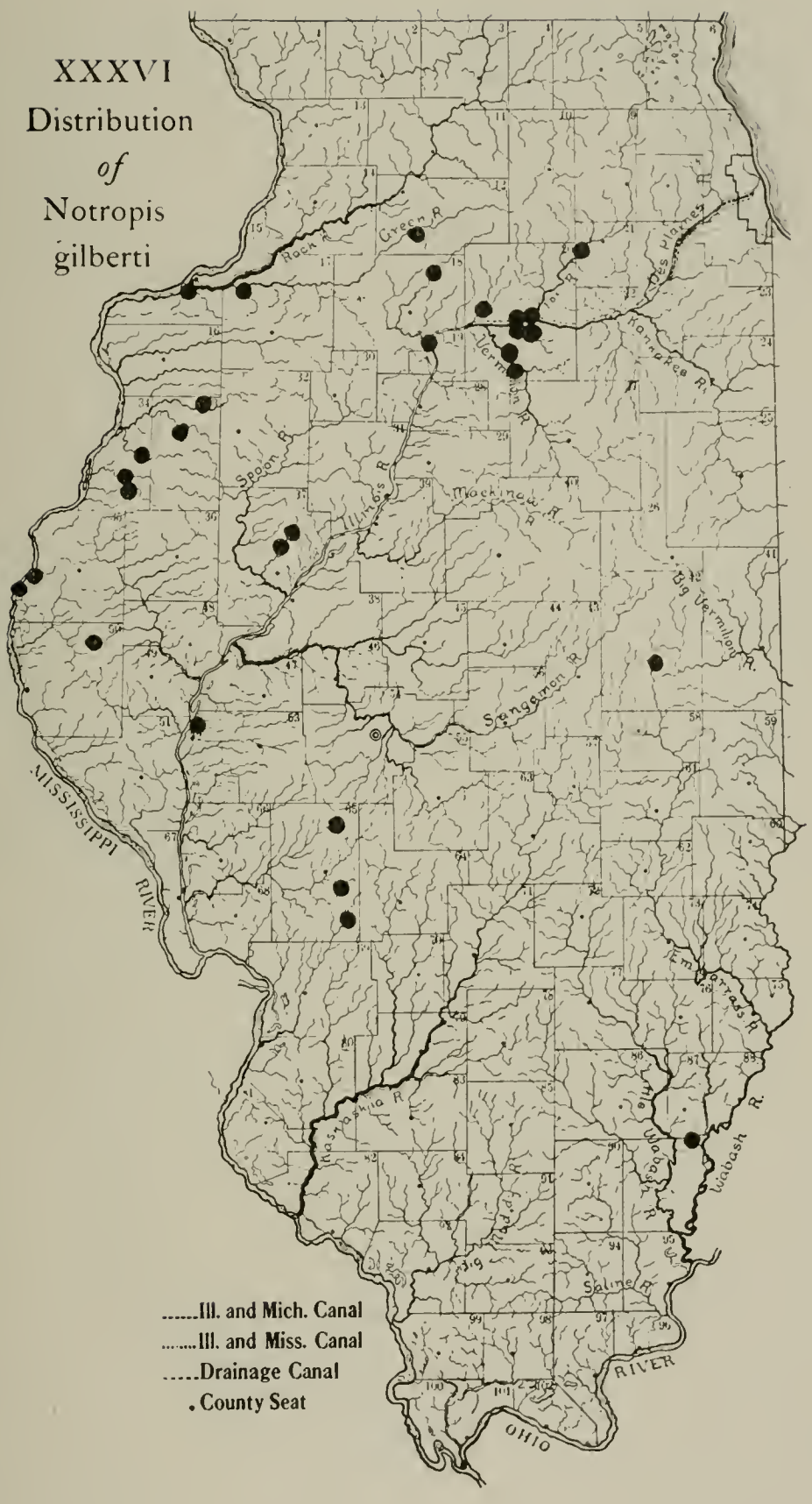
XXXIII
Distribution
of
Notropis
cayuga



XXXIV
Distribution
of
Notropis
heterodon




XXXV
Distribution
of
Notropis
blennius
Rock R.
Green R.
Des Plaines R.
Kankakee R.
Vermilion R.
Spoon R.
Illinois R.
Mackinaw R.
Sangamon R.
Embarras R.
Little Wabash R.
Wabash R.
Kaskaskia R.
Big Muddy R.
Saline R.
MISSISSIPPI RIVER
OHIO RIVER
.....Ill. and Mich. Canal
.....Ill. and Miss. Canal
.....Drainage Canal
. County Seat


XXXVI
Distribution
of
Notropis
gilberti
Rock R.
Green R.
Des Plaines R.
Kankakee R.
Vermilion R.
Spoon R.
Illinois R.
Mackinaw R.
Big Vermilion R.
Sangamon R.
MISSISSIPPI
RIVER
Embarras R.
Little Wabash R.
Wabash R.
Saline R.
Big
OHIO
RIVER
.....Ill. and Mich. Canal
.....Ill. and Miss. Canal
.....Drainage Canal
. County Seat

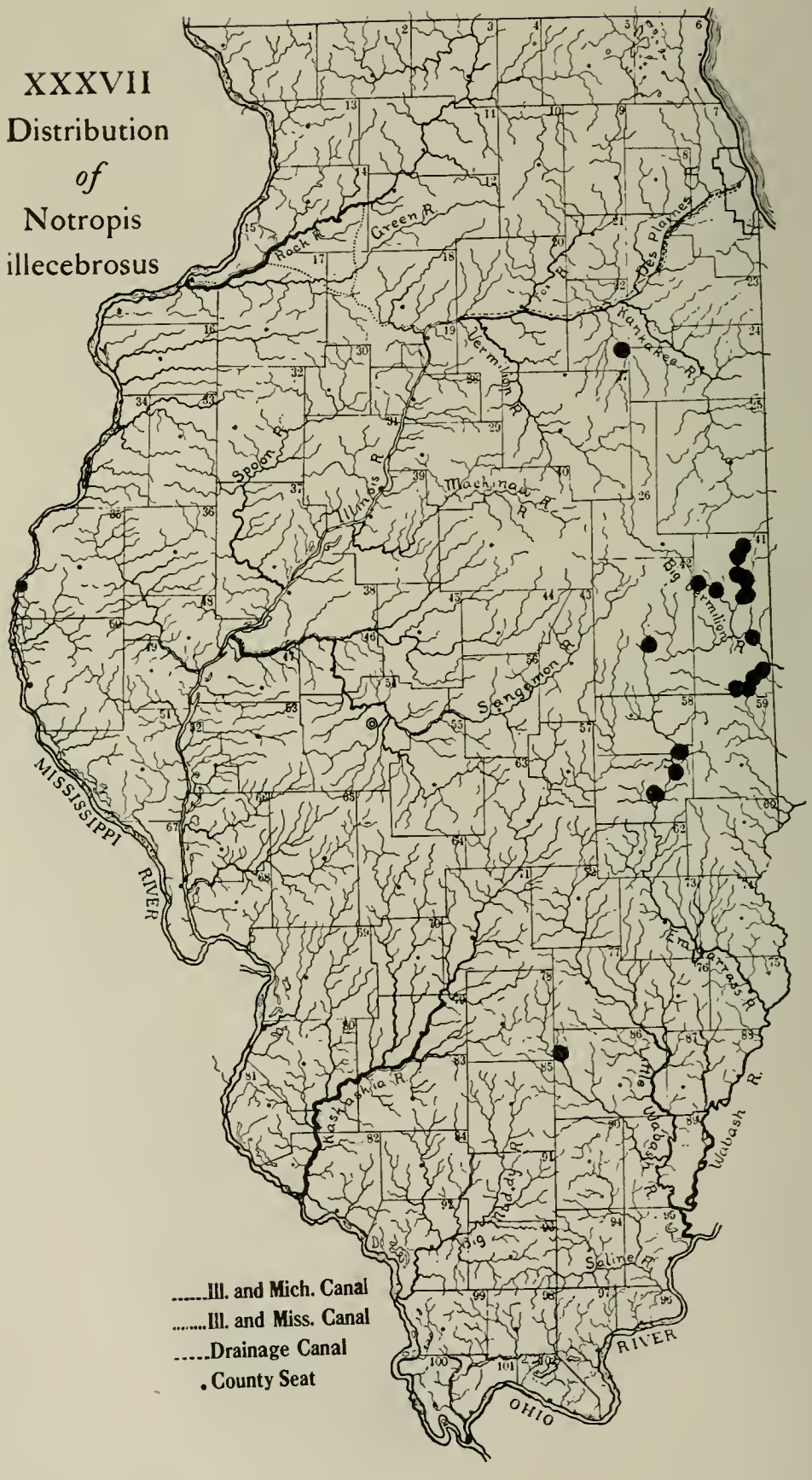
XXXVII

Distribution

of

Notropis

illecebrosus



XXXVIII

Distribution *of* Notropis hudsonius

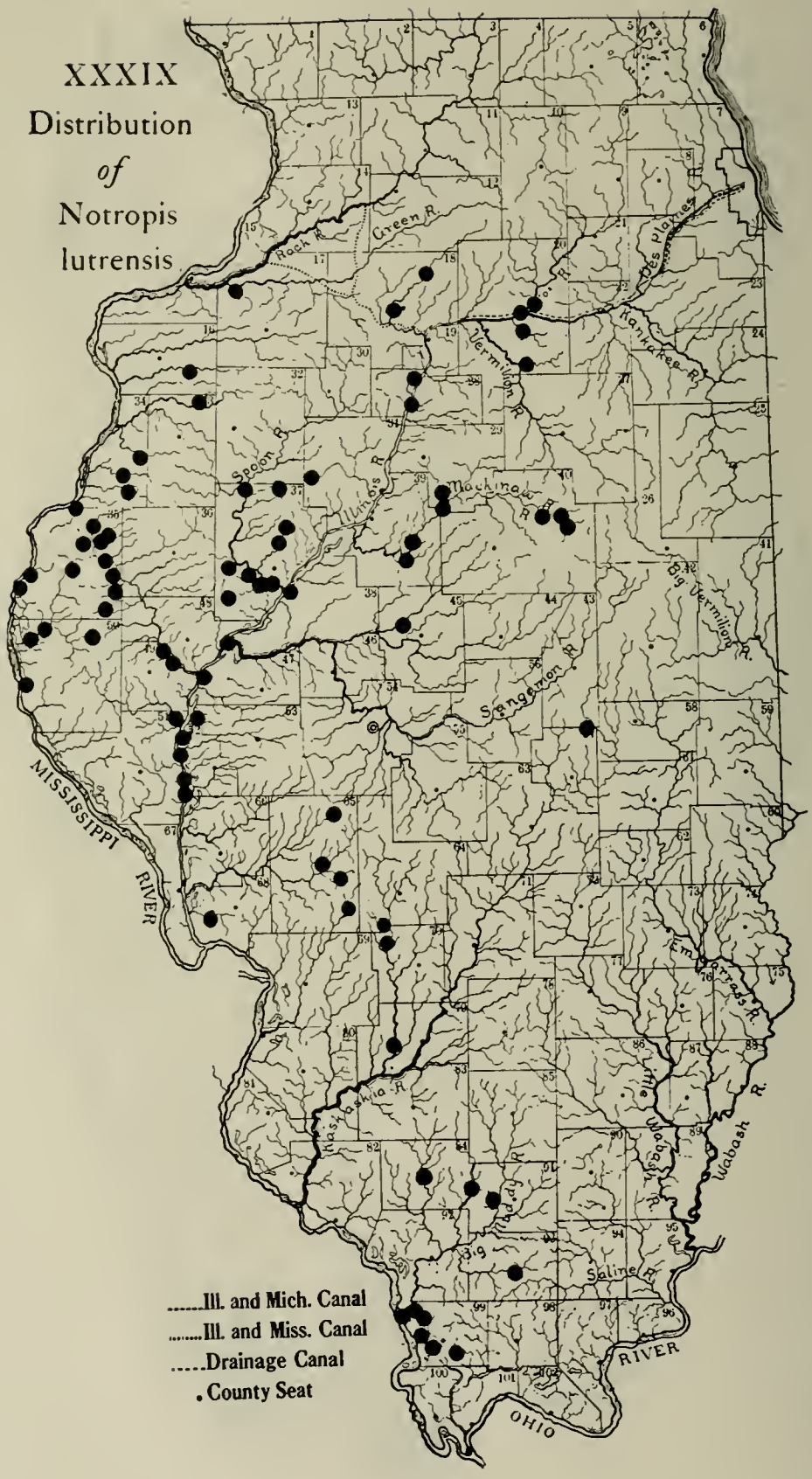
XXXIX

Distribution

of

Notropis

lutrensis



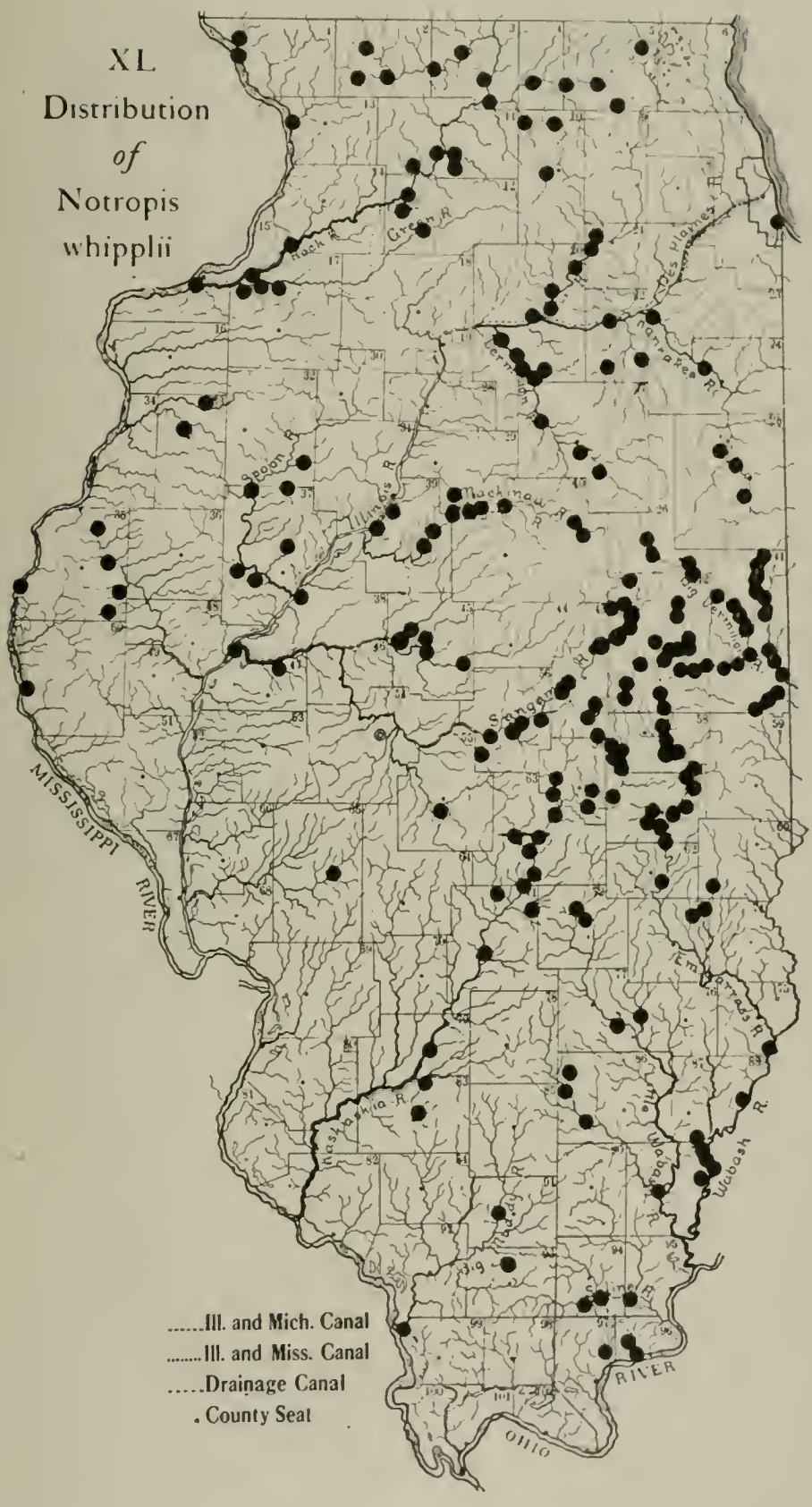
XL

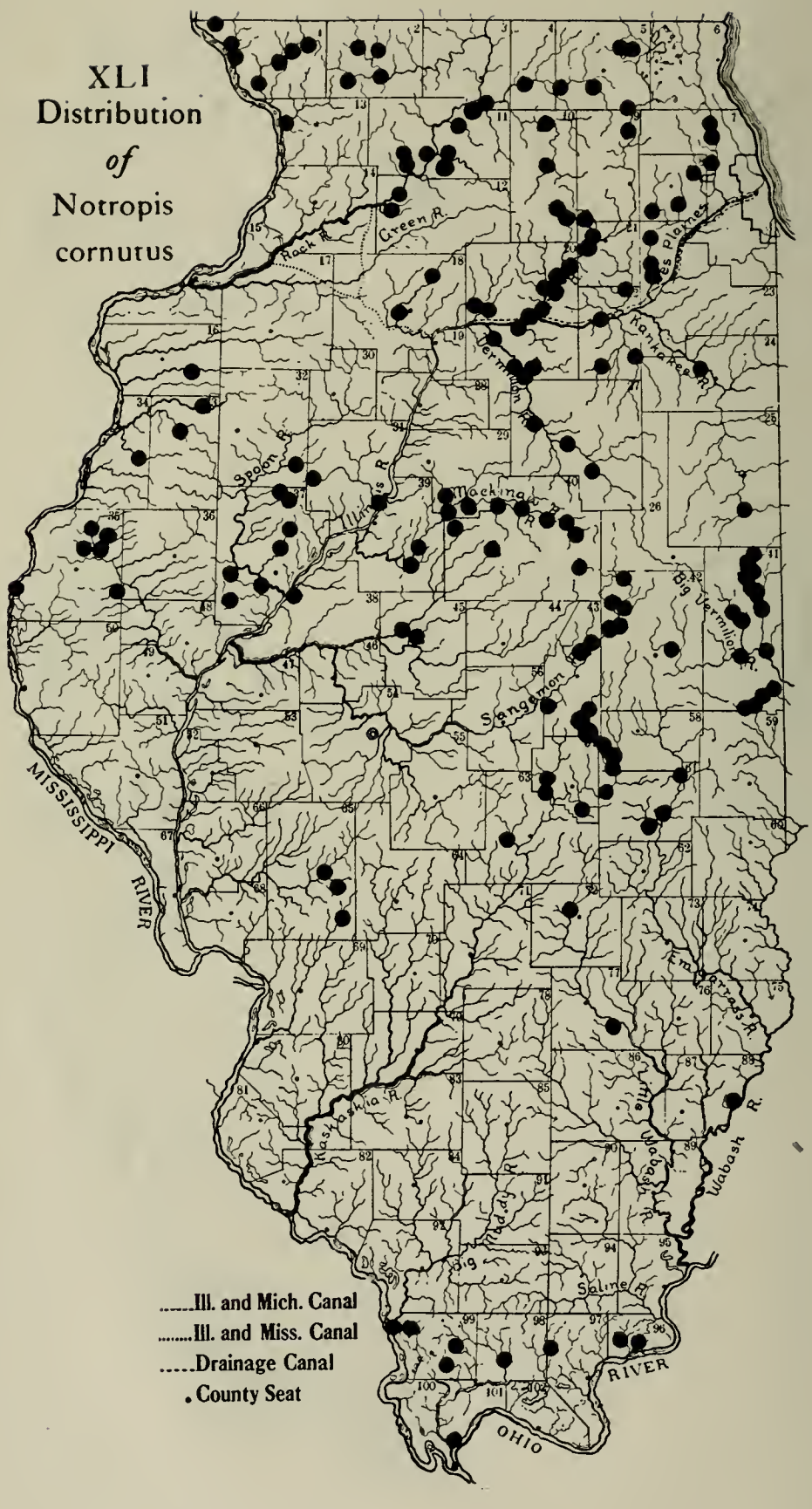
Distribution

of

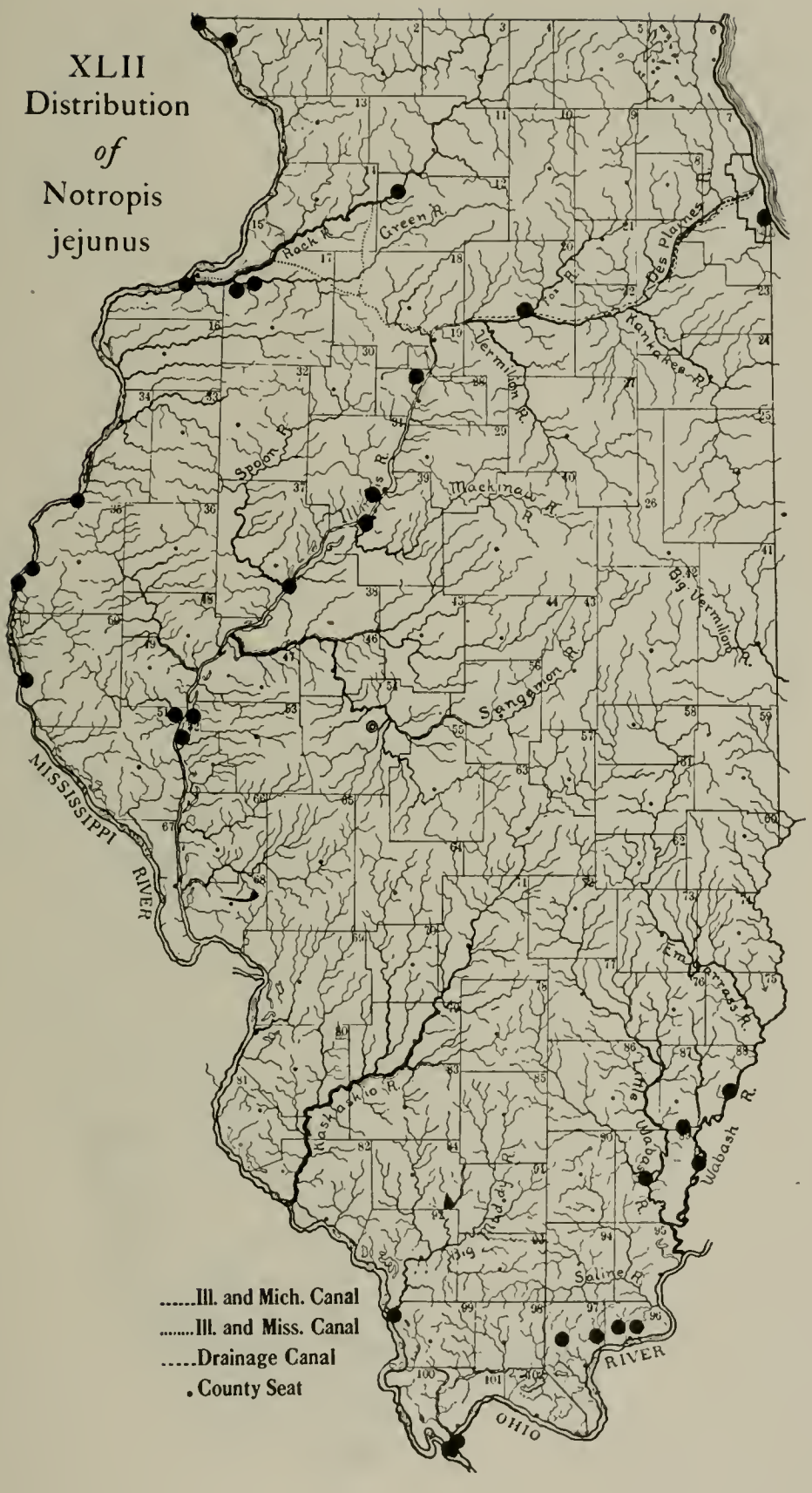
Notropis

whipplii




XLI
Distribution
of
Notropis
cornutus
Rock R.
Green R.
Des Plaines R.
Kankakee R.
Vermilion R.
Sangamon R.
Mackinaw R.
Spoon R.
Illinois R.
MISSISSIPPI RIVER
Kaskaskia R.
Little Wabash R.
Wabash R.
Big Muddy R.
Saline R.
OHIO RIVER
.....Ill. and Mich. Canal
.....Ill. and Miss. Canal
.....Drainage Canal
. County Seat

XLII
Distribution
of
Notropis
jejunus



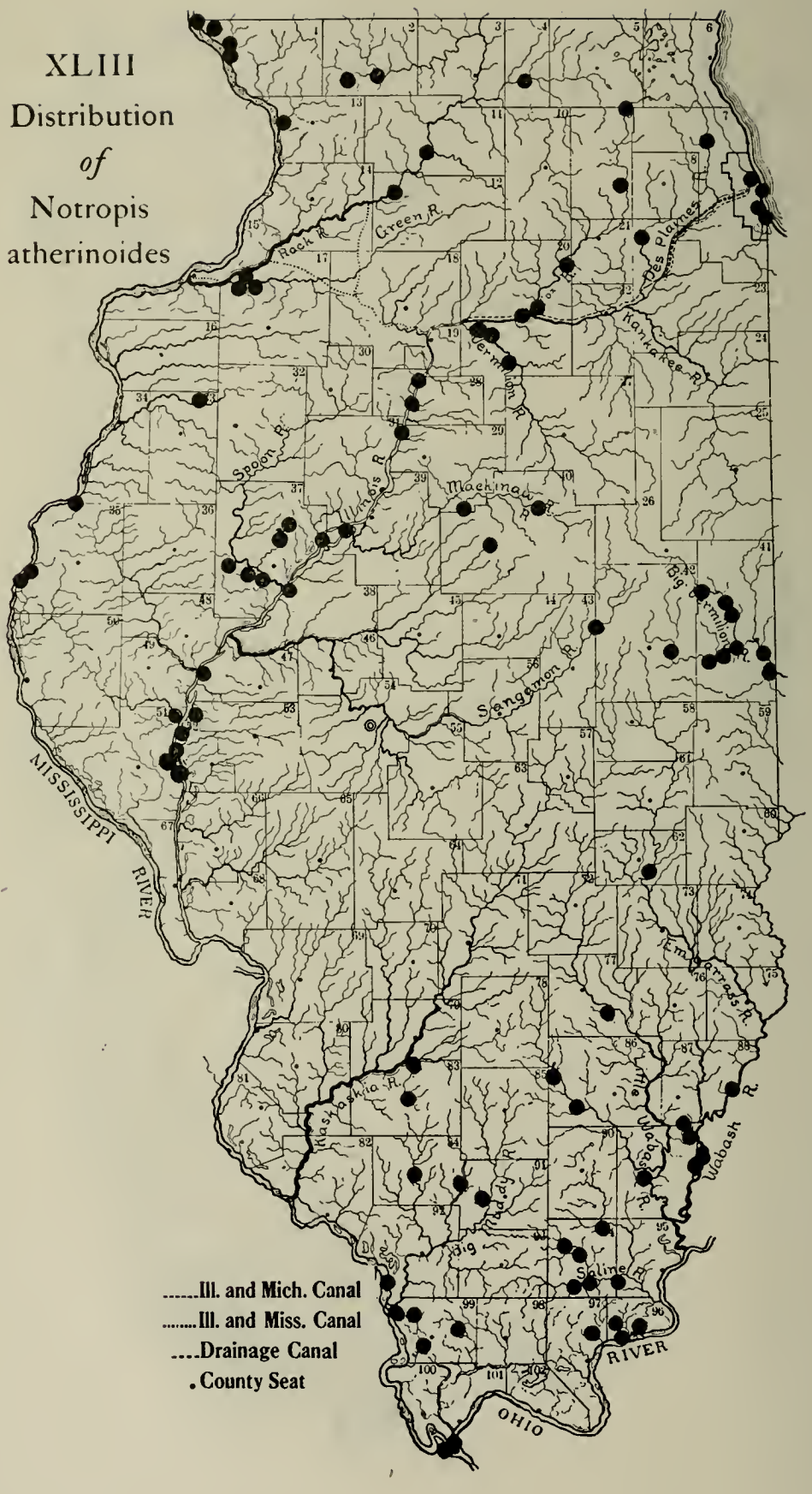
XLIII

Distribution

of

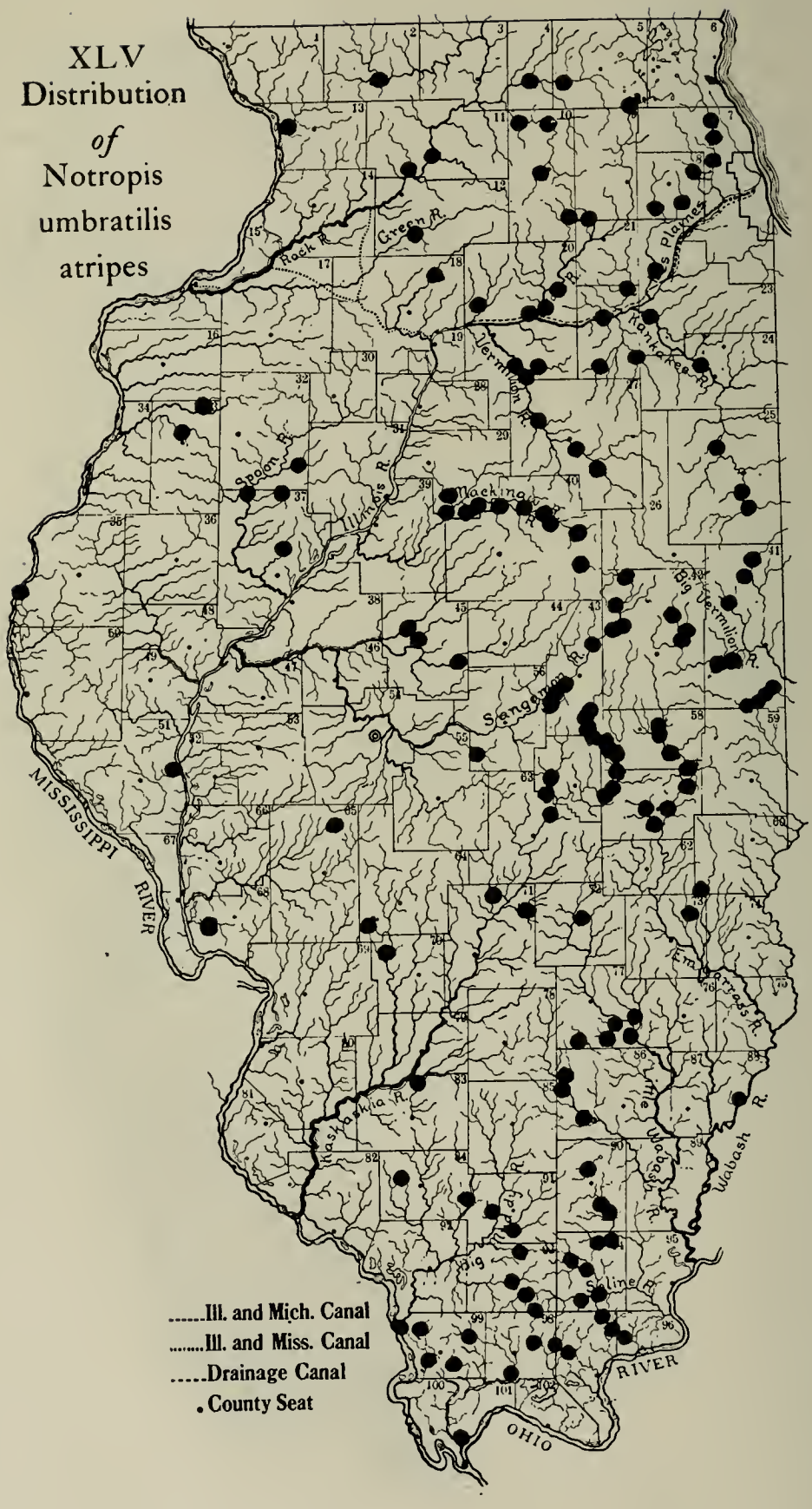
Notropis

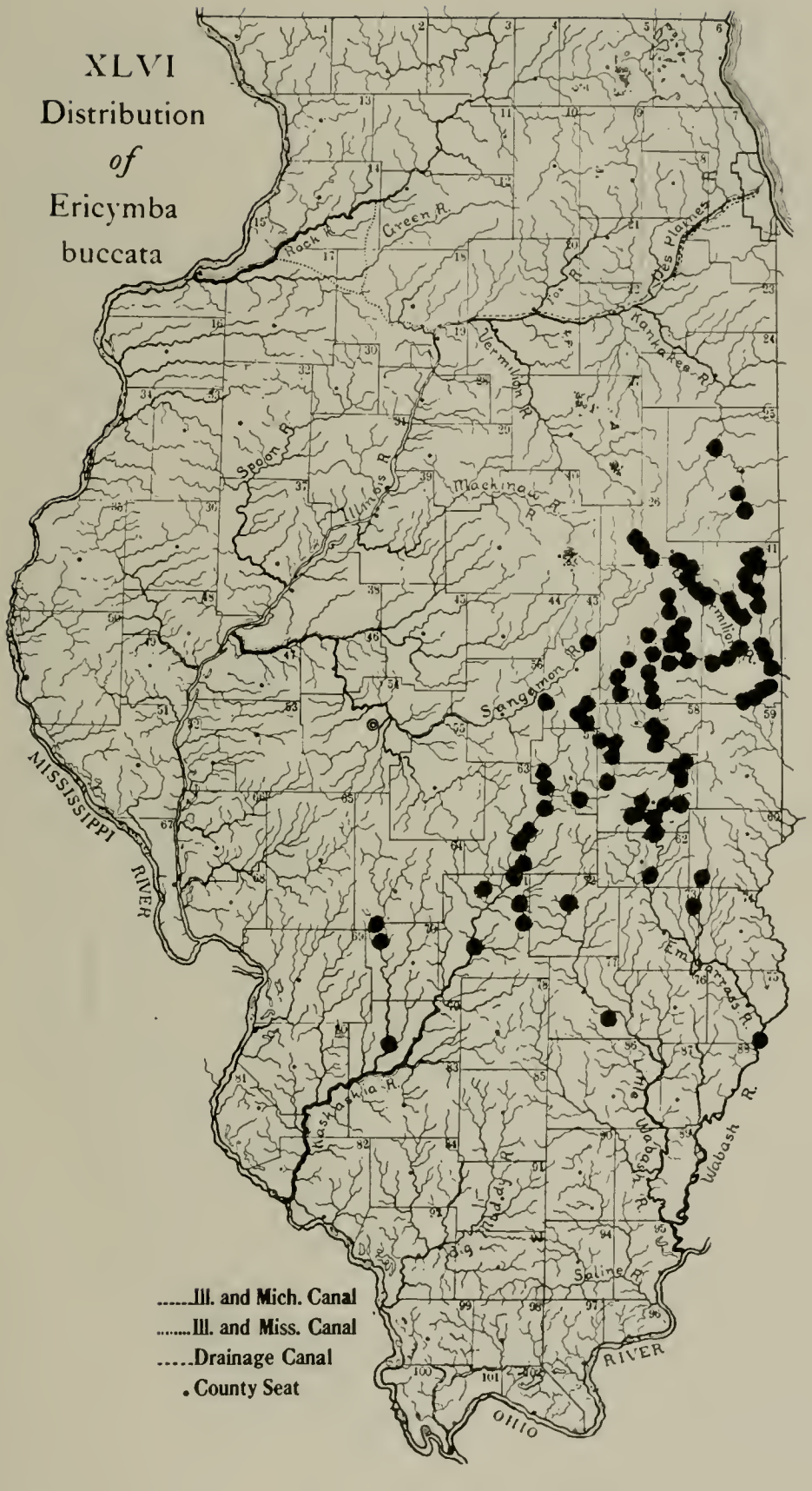
atherinoides

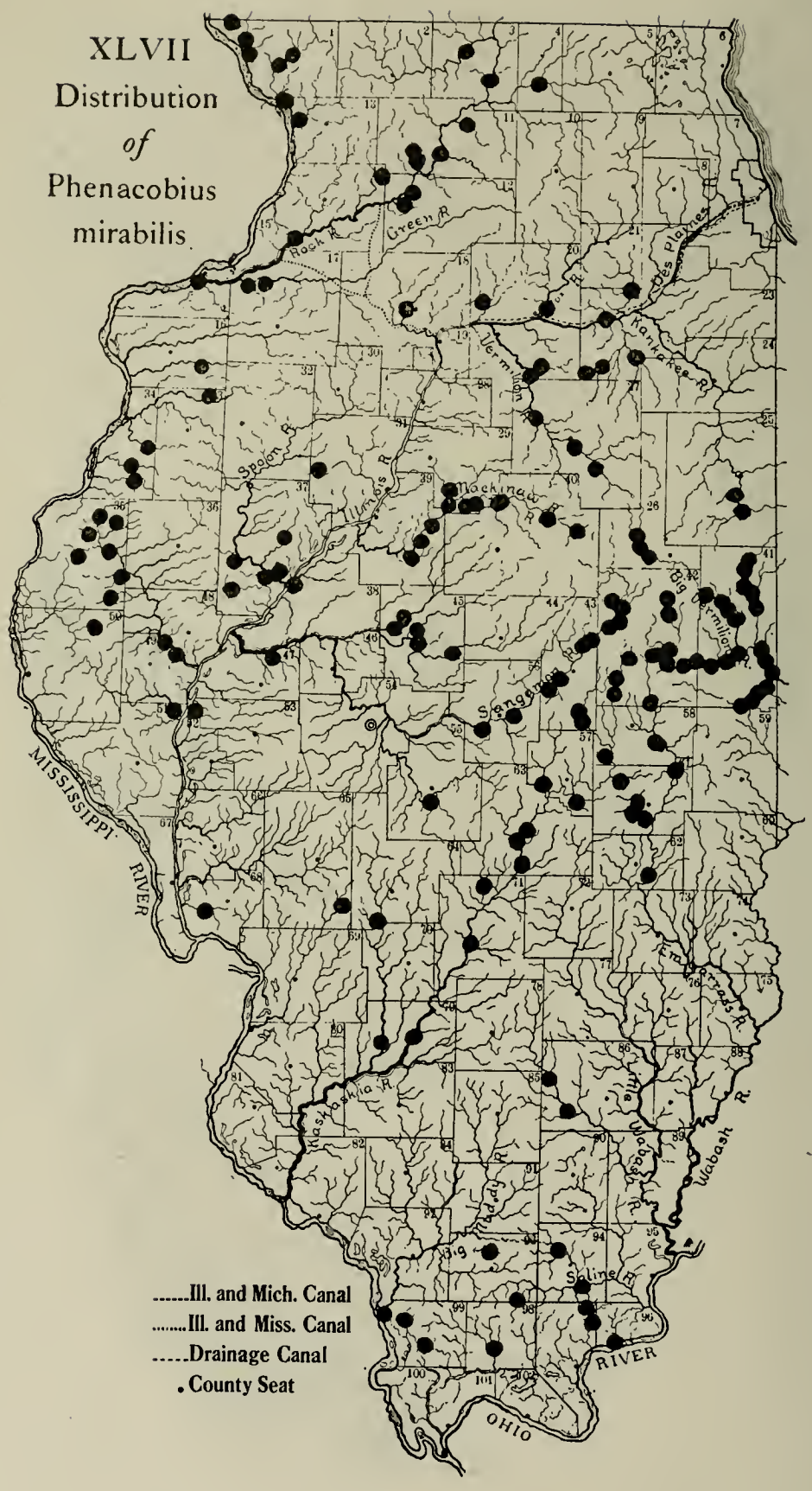



XLIV
Distribution
of
Notropis
rubrifrons
Rock R.
Green R.
Des Plaines R.
Kankakee R.
Vermilion R.
Spoon R.
Illinois R.
Mackinaw R.
Sangamon R.
Vermilion R.
MISSISSIPPI RIVER
Embarras R.
Wabash R.
Little Wabash R.
Kaskaskia R.
Big Muddy R.
Saline R.
OHIO RIVER
.....Ill. and Mich. Canal
.....Ill. and Miss. Canal
.....Drainage Canal
. County Seat

XLV
Distribution
of
Notropis
umbratilis
atripes




XLVI
Distribution
of
Ericymba
buccata
Rock R.
Green R.
Fox R.
Kankakee R.
Vermilion R.
Spoon R.
Illinois R.
Mackinaw R.
Sangamon R.
Vermilion R.
MISSISSIPPI RIVER
Embarras R.
Kaskaskia R.
Little Wabash R.
Wabash R.
Big Muddy R.
Saline R.
OHIO RIVER
.....Ill. and Mich. Canal
.....Ill. and Miss. Canal
.....Drainage Canal
. County Seat


XLVII
Distribution
of
Phenacobius
mirabilis
Rock R.
Green R.
Des plaines R.
Kankakee R.
Vermilion R.
Spoon R.
Illinois R.
Mackinaw R.
Big Vermilion R.
Sangamon R.
MISSISSIPPI RIVER
Embarras R.
Little Wabash R.
Wabash R.
Saline R.
RIVER
OHIO
.....Ill. and Mich. Canal
.....Ill. and Miss. Canal
.....Drainage Canal
. County Seat

XLVIII
Distribution
of
Hybopsis
dissimilis

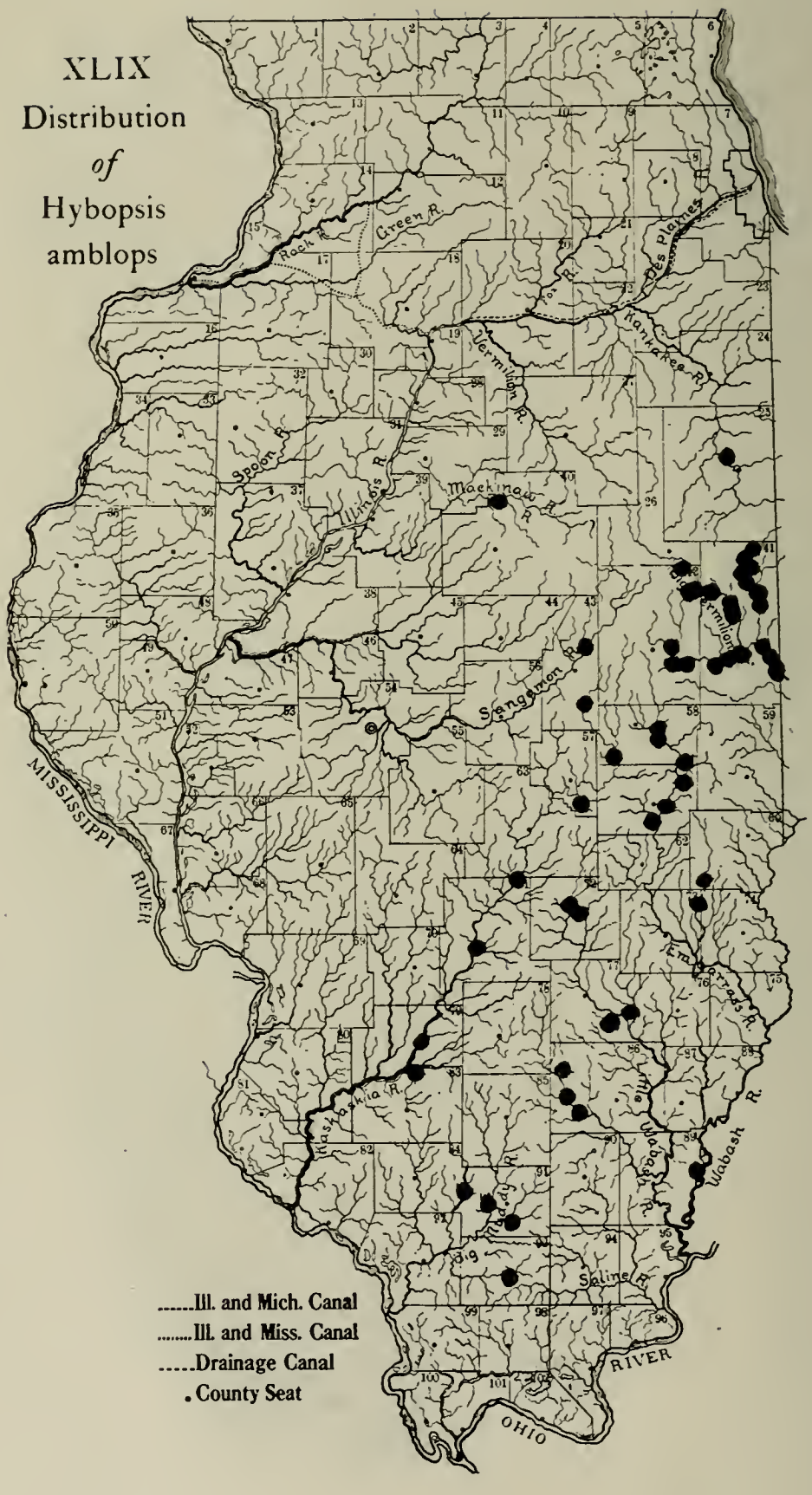
XLIX

Distribution

of

Hybopsis

amblops




L
Distribution
of
Hybopsis
storerianus
Rock R.
Green R.
Des Plaines R.
Kankakee R.
Vermilion R.
Spoon R.
Illinois R.
Mackinaw R.
Big Vermilion R.
Sangamon R.
MISSISSIPPI RIVER
Embarras R.
Wabash R.
Saline R.
OHIO RIVER
.....Ill. and Mich. Canal
.....Ill. and Miss. Canal
.....Drainage Canal
. County Seat

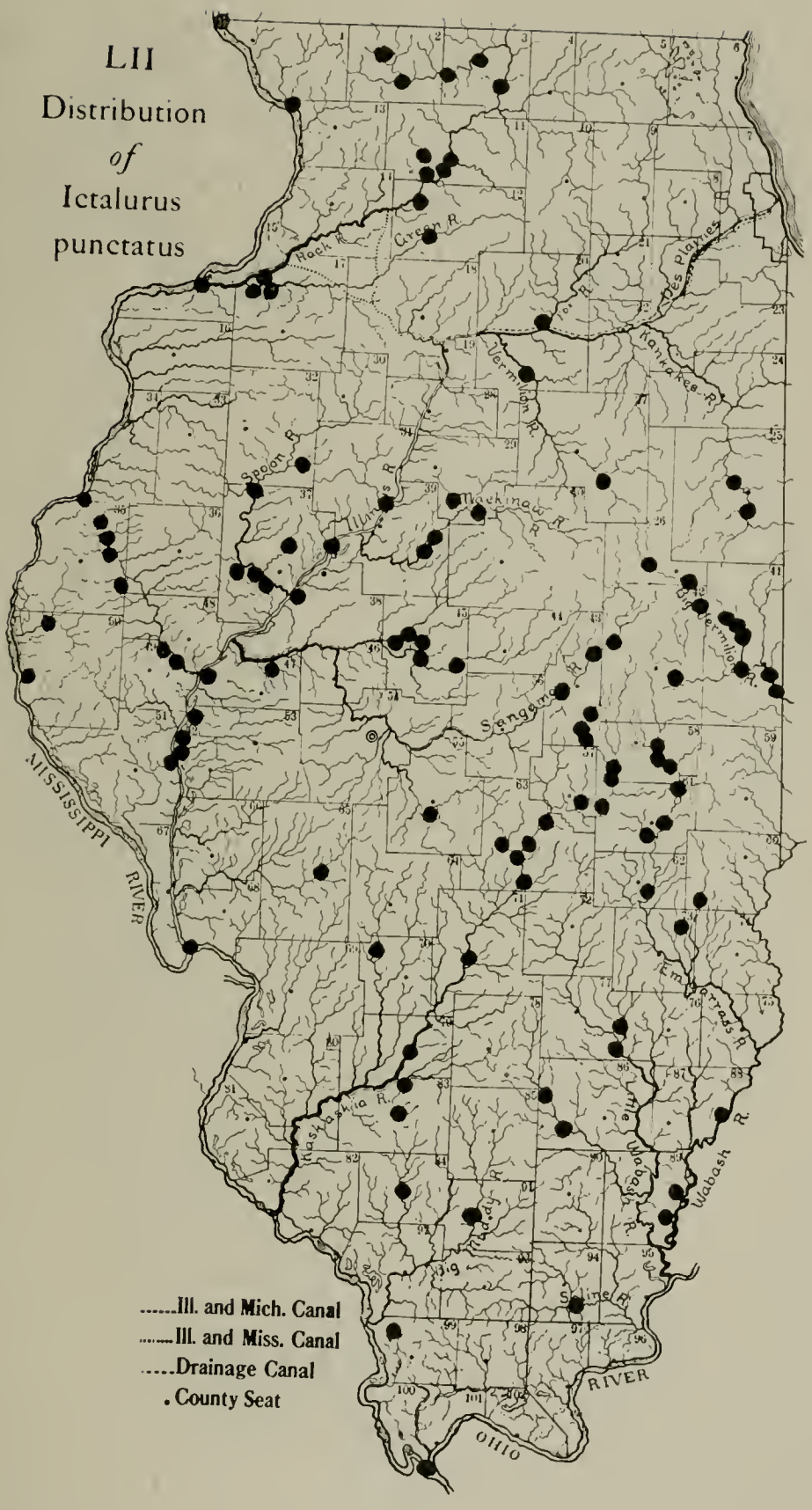
LI

Distribution

of

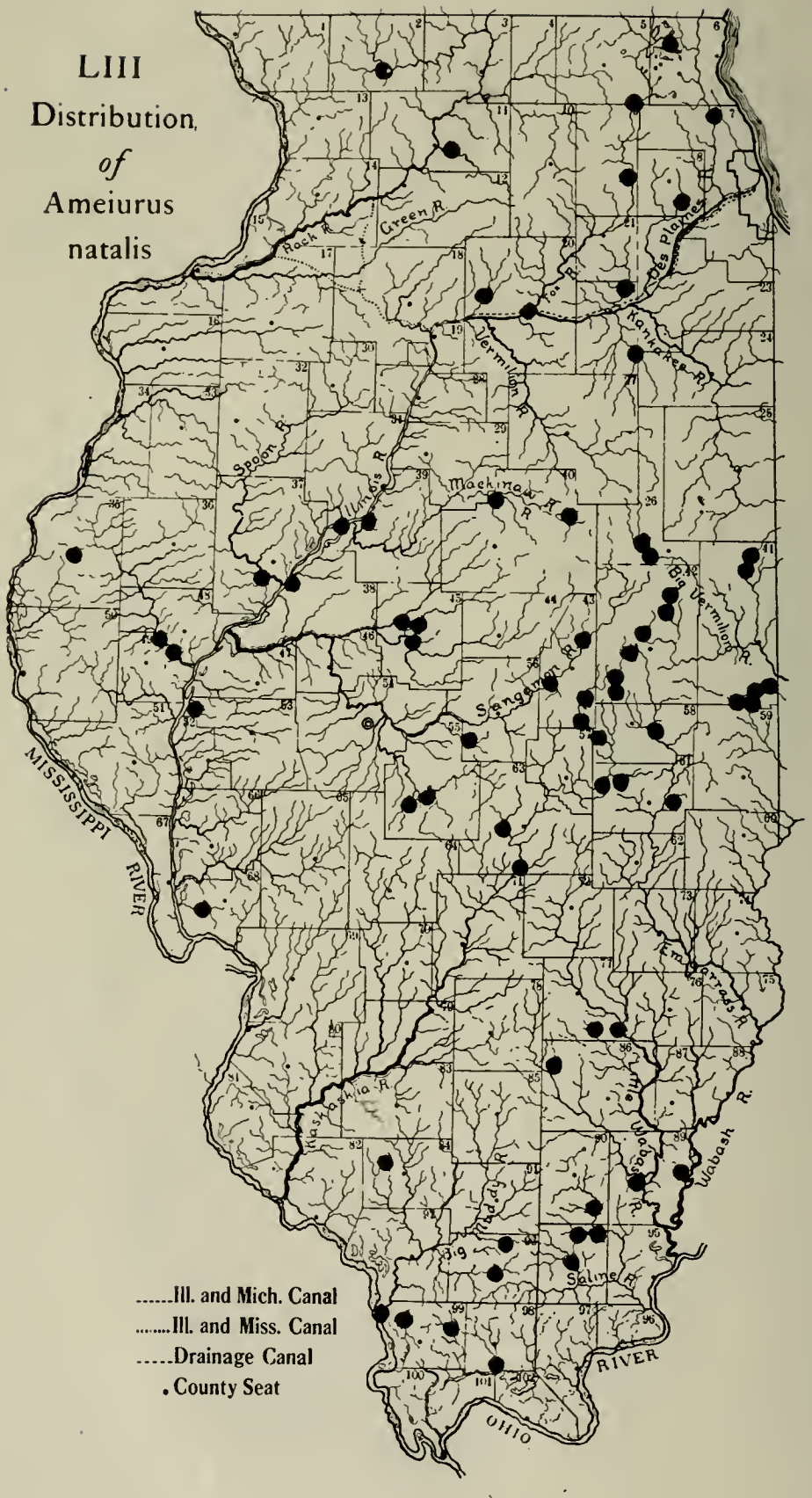
Hybopsis

kentuckiensis


LII
Distribution
of
Ictalurus
punctatus
Rock R.
Green R.
Des Plaines R.
Kankakee R.
Vermilion R.
Spoon R.
Illinois R.
Mackinaw R.
Sangamon R.
Mississippi River
Embarras R.
Wabash R.
Little Wabash R.
Kaskaskia R.
Big Muddy R.
Saline R.
Ohio River
.....Ill. and Mich. Canal
.....Ill. and Miss. Canal
.....Drainage Canal
. County Seat

LIII

Distribution
of
Ameiurus
natalis



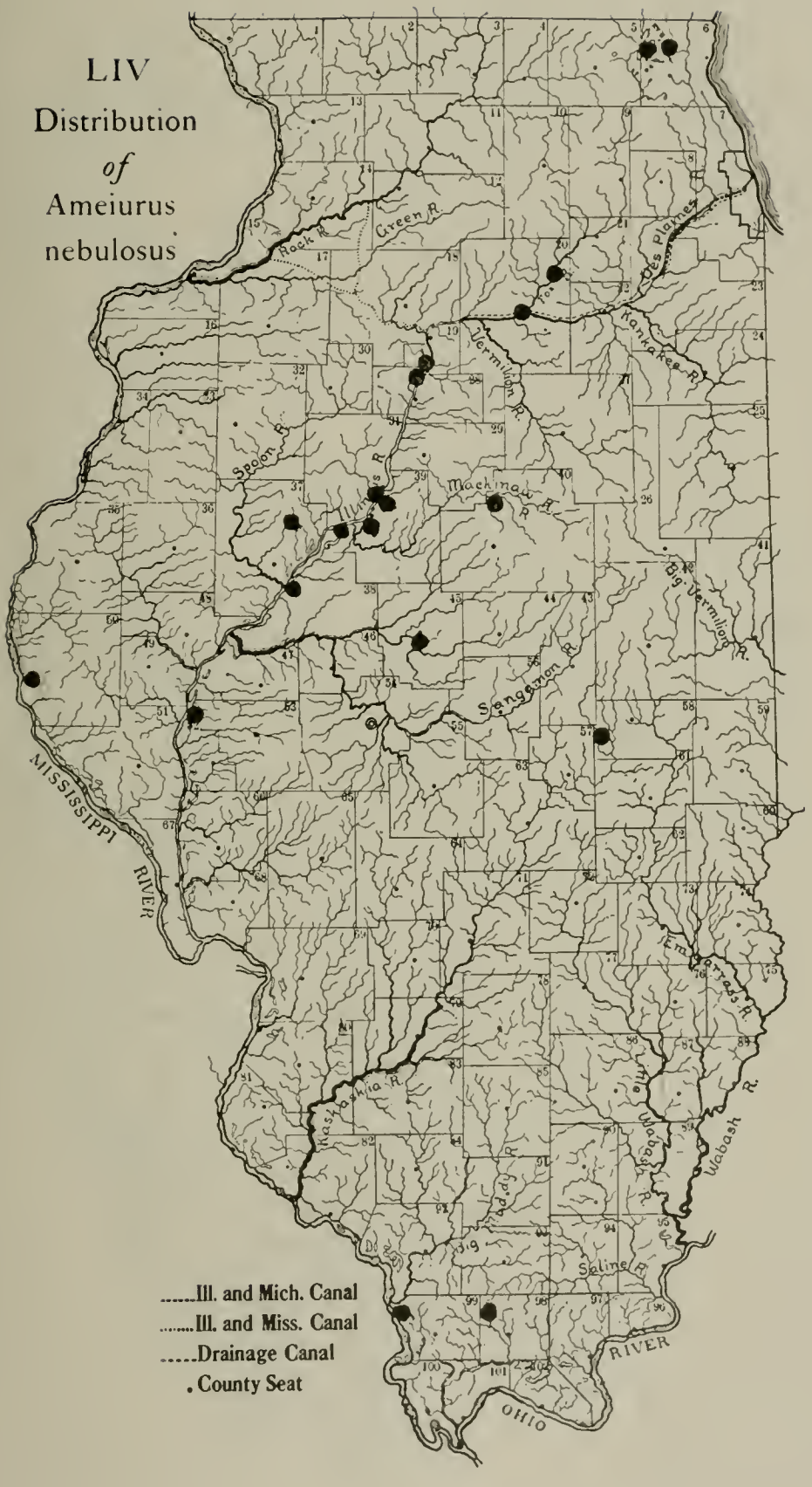
LIV

Distribution

of

Ameiurus

nebulosus



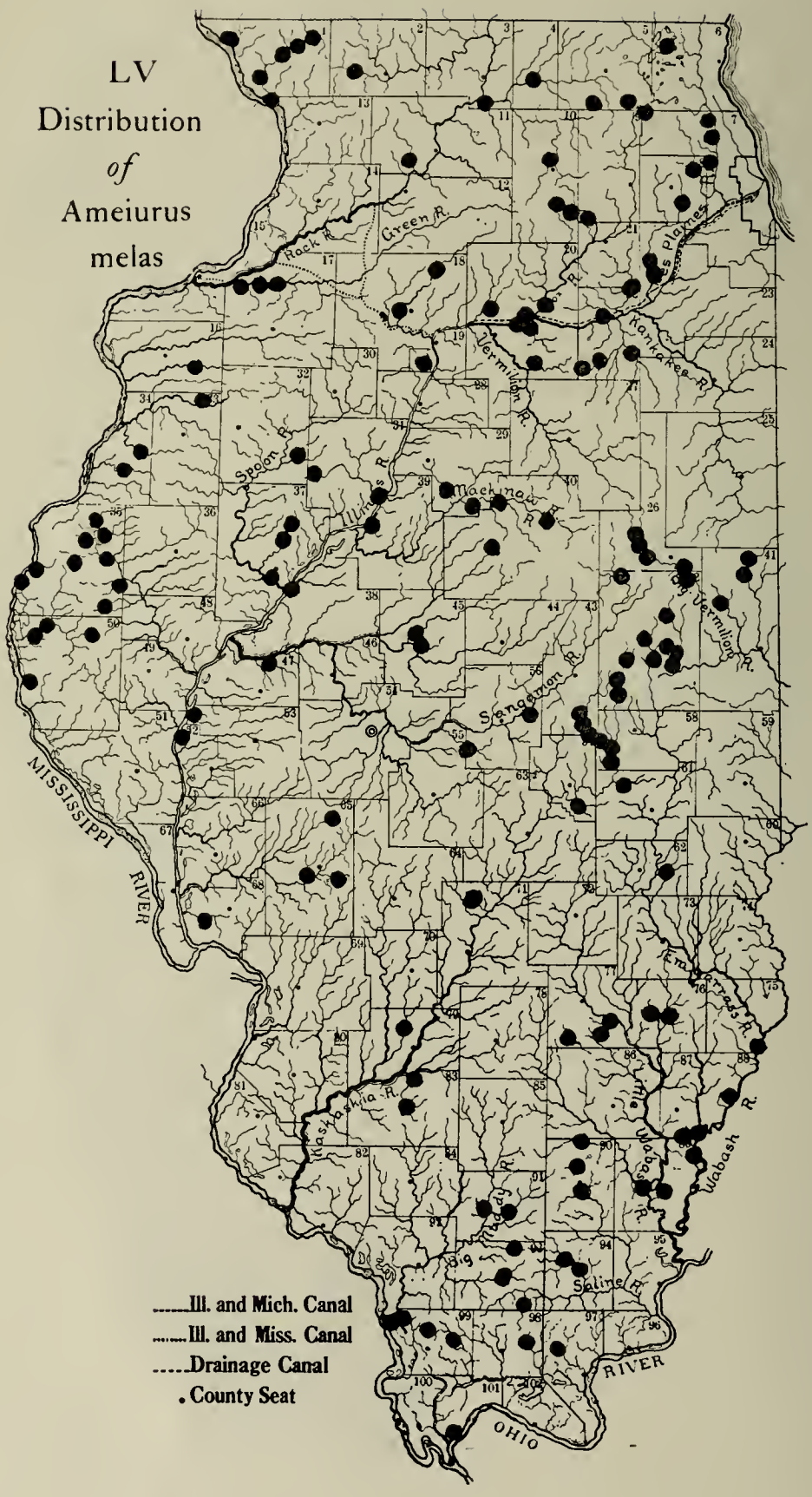
LV

Distribution

of

Ameiurus

melas



LVI

Distribution

of

Leptops

olivaris

LVII

Distribution

of

Noturus

flavus

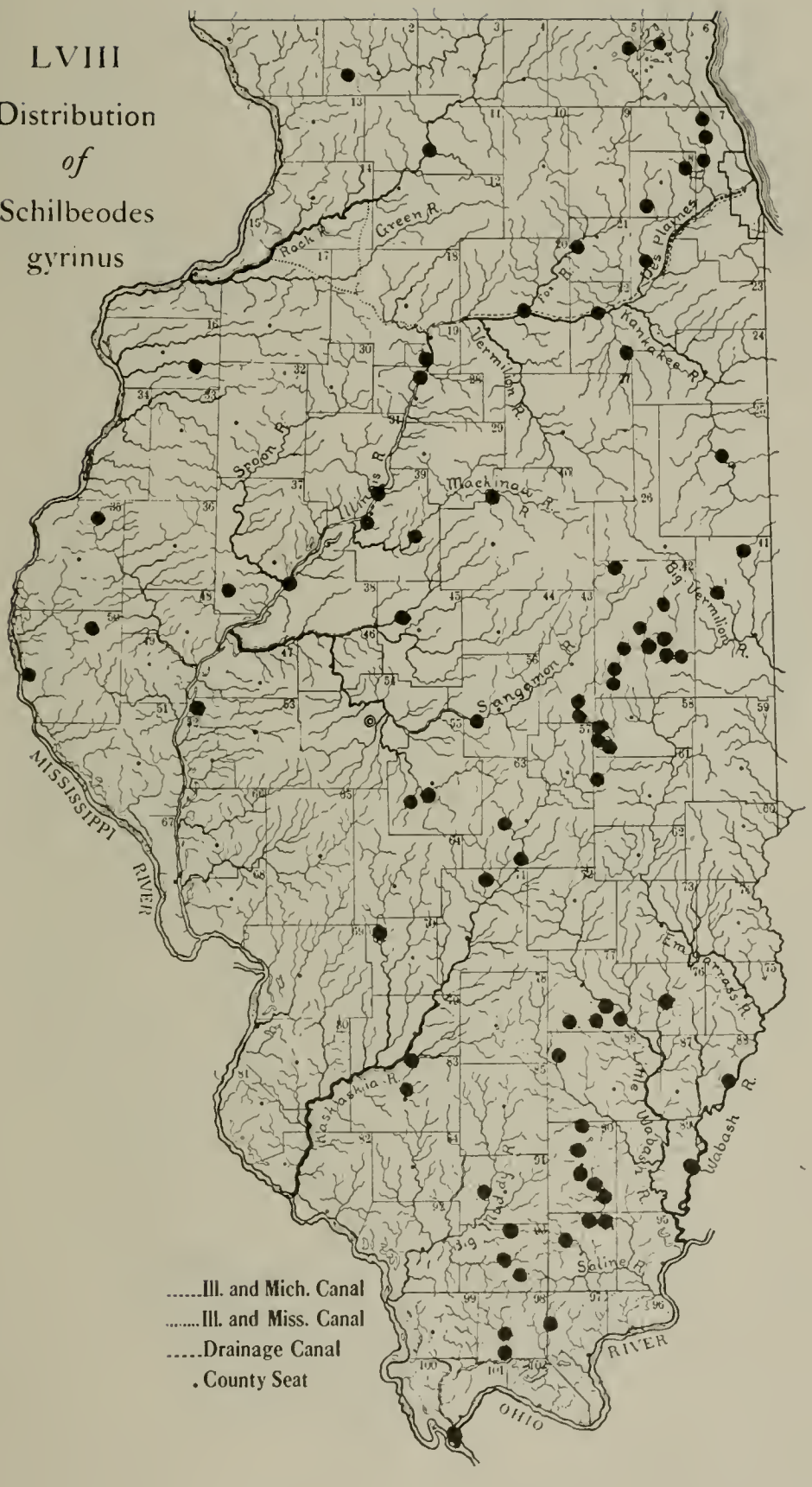
LVIII

Distribution

of

Schilbeodes

gyrinus



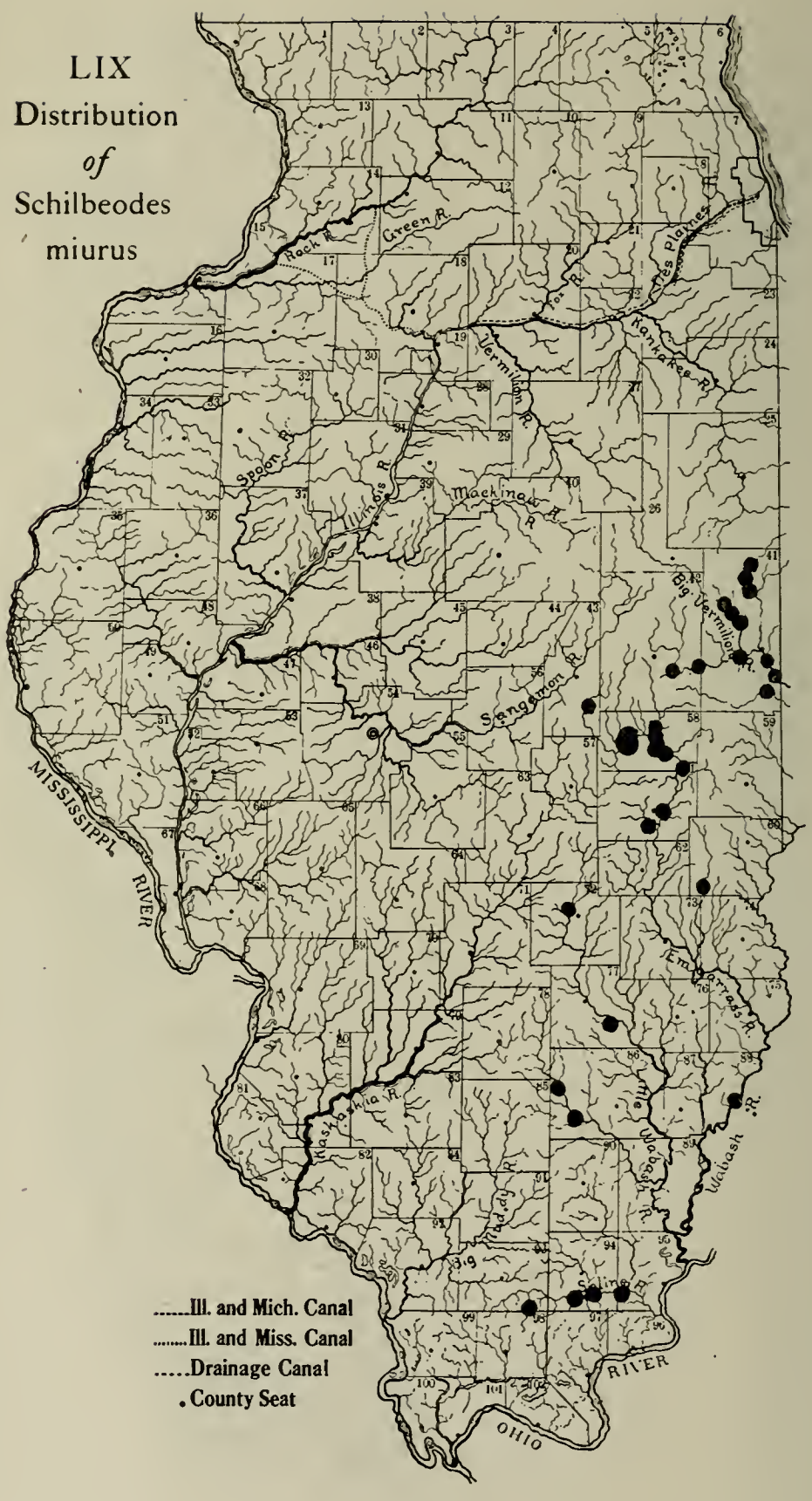
LIX

Distribution

of

Schilbeodes

miurus



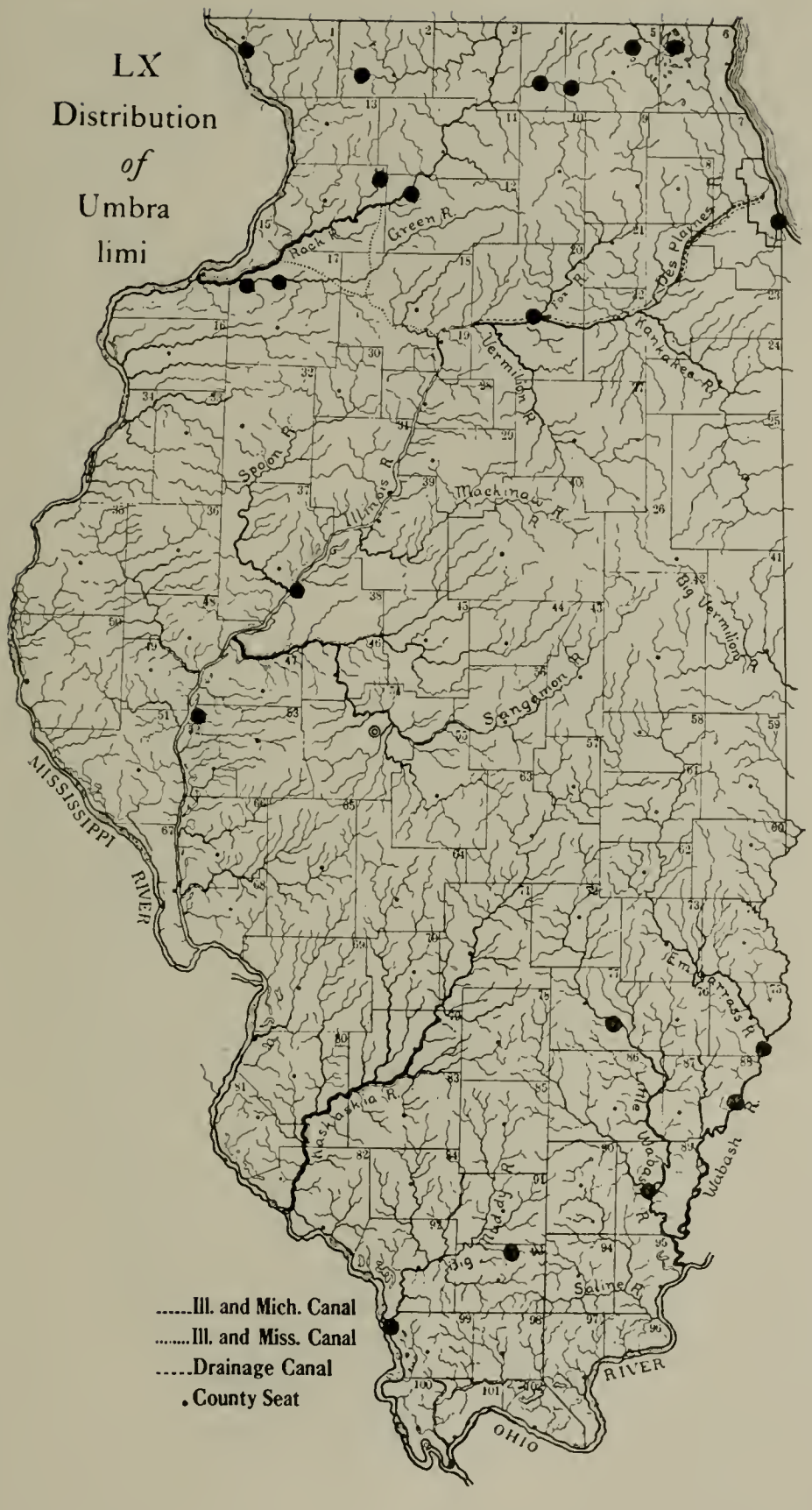
LX

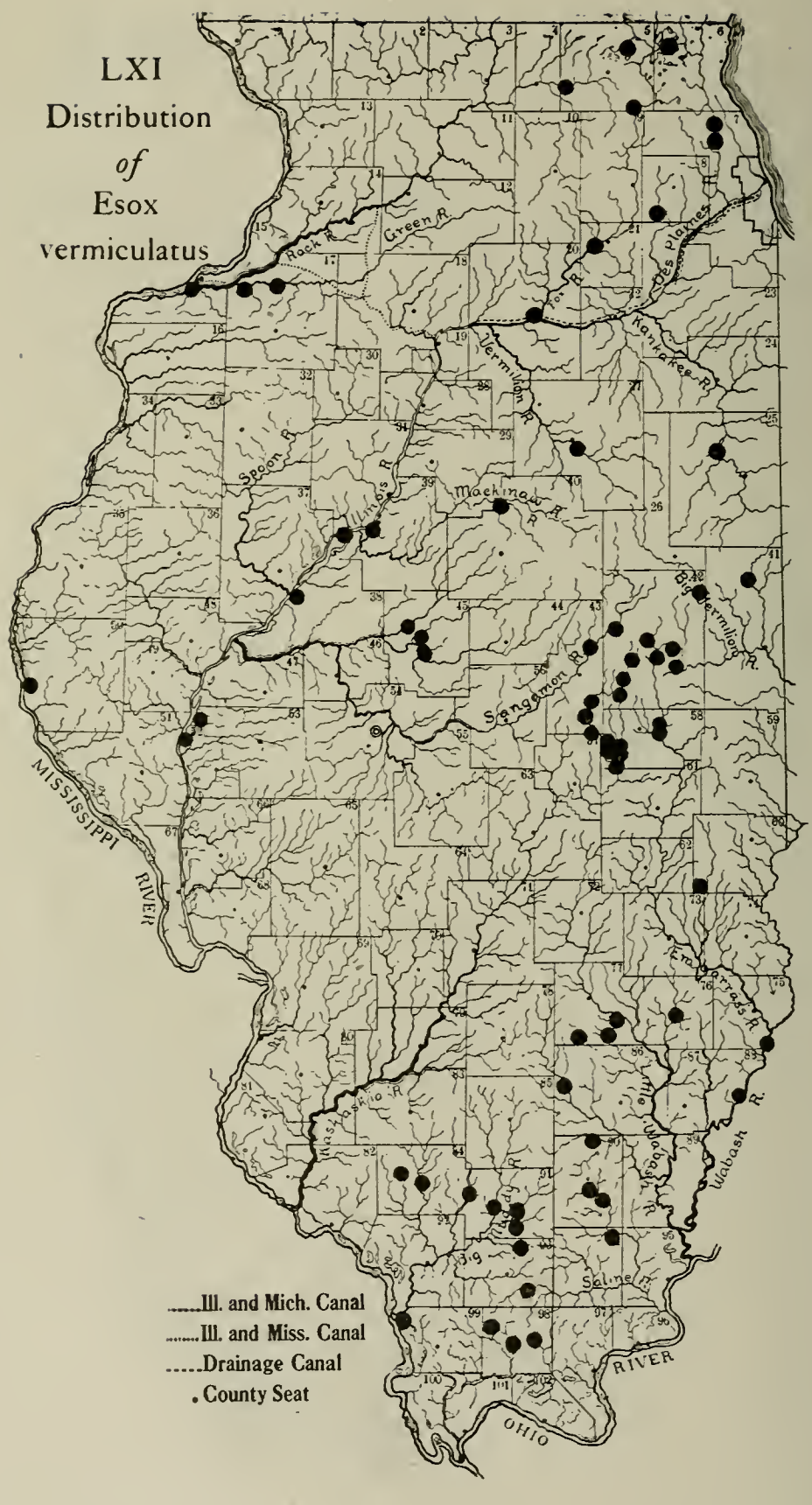
Distribution

of

Umbra

limi



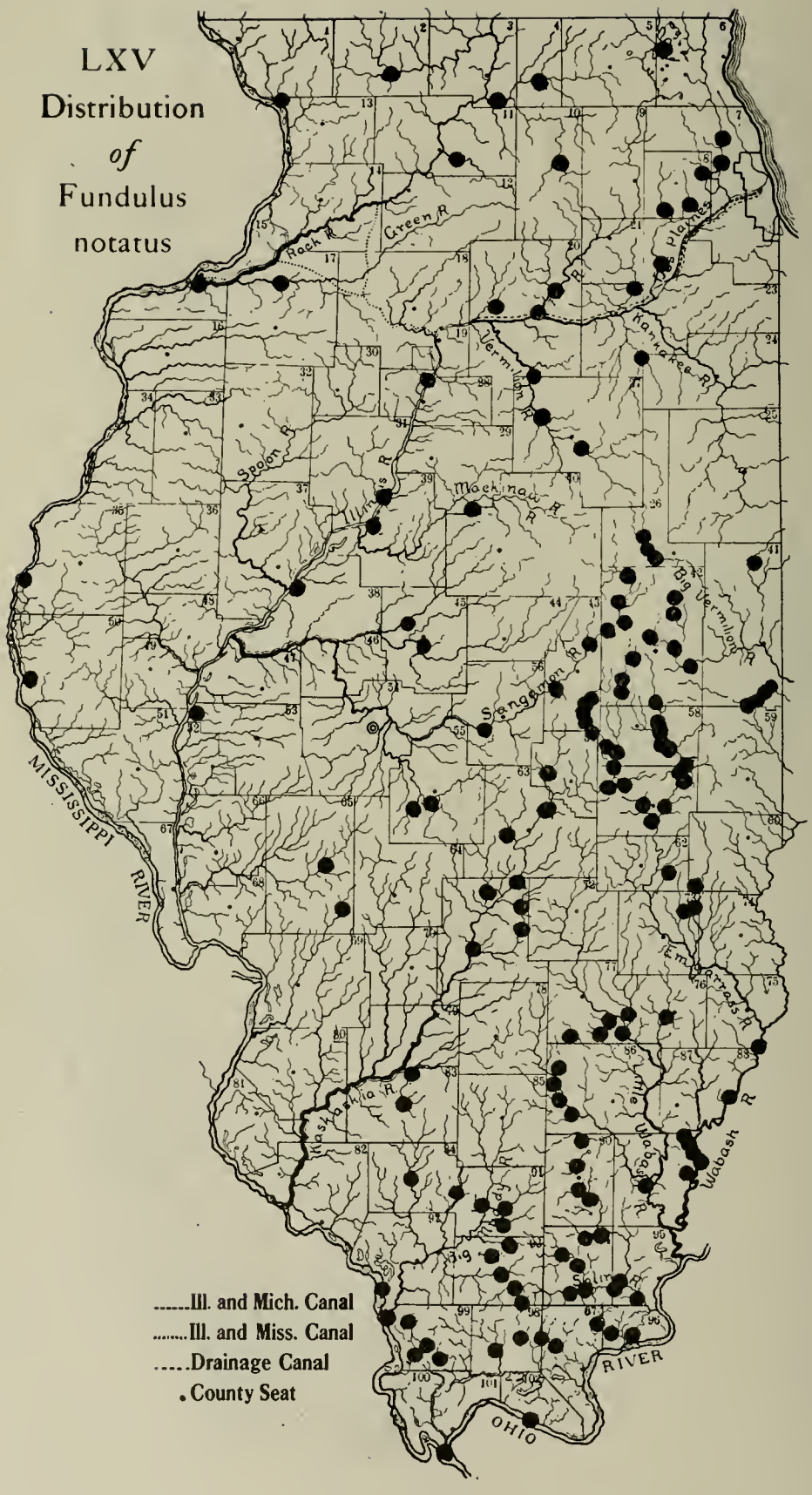

LXI
Distribution
of
Esox
vermiculatus
Rock R.
Green R.
Des Plaines R.
Kankakee R.
Vermilion R.
Spoon R.
Illinois R.
Mackinaw R.
Big Vermilion R.
Sangamon R.
MISSISSIPPI RIVER
Embarras R.
Little Wabash R.
Wabash R.
Big Muddy R.
Saline R.
OHIO RIVER
.....Ill. and Mich. Canal
.....Ill. and Miss. Canal
.....Drainage Canal
. County Seat

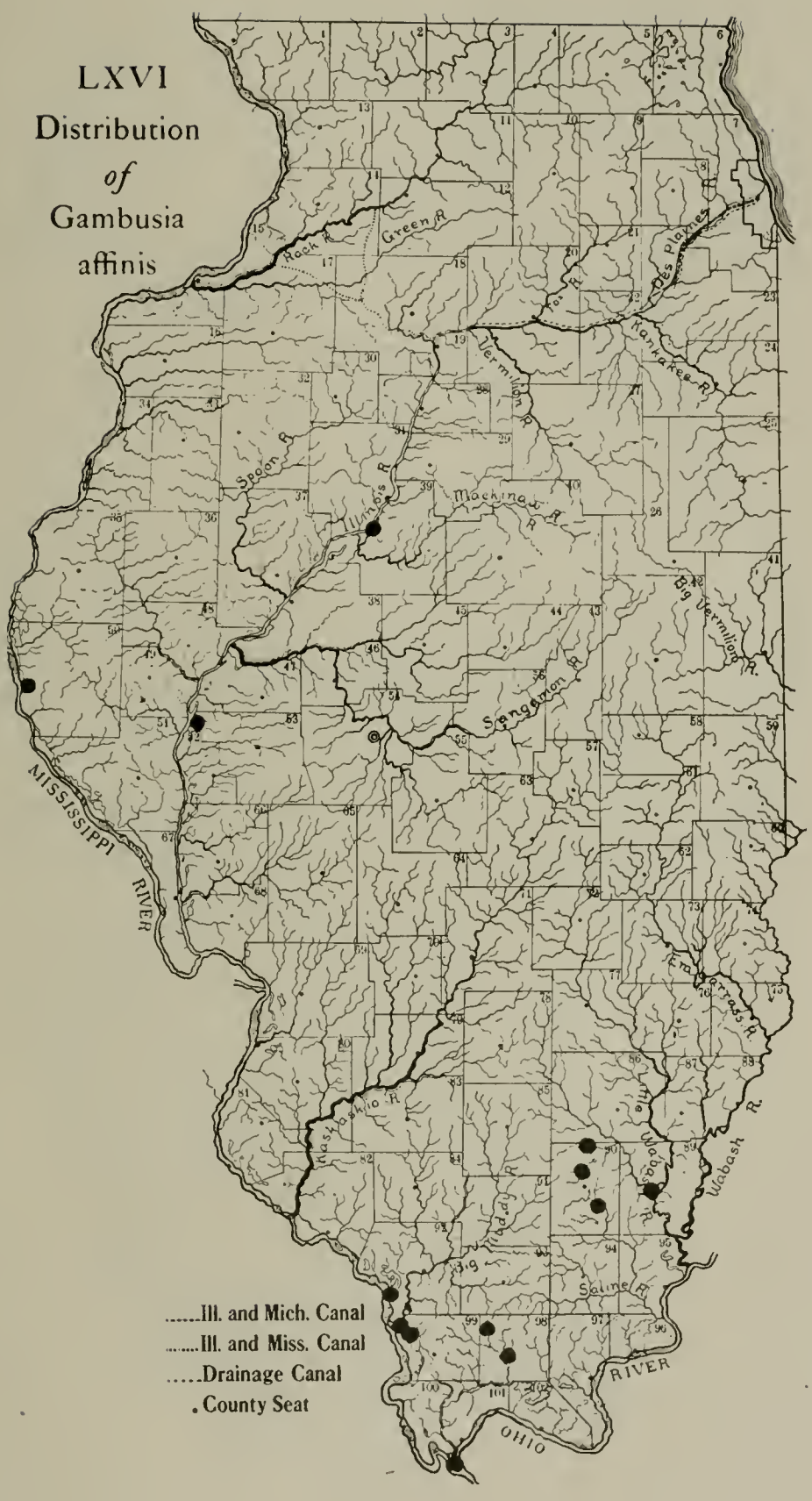

LXII
Distribution
of
Esox
lucius
Rock R.
Green R.
Des Plaines R.
Kankakee R.
Vermilion R.
Illinois R.
Spoon R.
Mackinaw R.
Big Vermilion R.
Sangamon R.
MISSISSIPPI RIVER
Embarras R.
Little Wabash R.
Wabash R.
Big Muddy R.
Saline R.
RIVER
OHIO
.....Ill. and Mich. Canal
.....Ill. and Miss. Canal
.....Drainage Canal
. County Seat

LXIII
Distribution
of
Fundulus
diaphanus
menona


LXIV
Distribution
of
Fundulus
dispar
Rock R.
Green R.
Des Plaines R.
Kankakee R.
Vermilion R.
Spoon R.
Illinois R.
Mackinaw R.
Big Vermilion R.
Sangamon R.
MISSISSIPPI RIVER
Embarras R.
Little Wabash R.
Wabash R.
Kaskaskia R.
Big Muddy R.
Saline R.
OHIO RIVER
.....Ill. and Mich. Canal
.....Ill. and Miss. Canal
.....Drainage Canal
. County Seat

LXV
Distribution
of
Fundulus
notatus




LXVI
Distribution
of
Gambusia
affinis
Rock R.
Green R.
Des Plaines R.
Kankakee R.
Vermilion R.
Illinois R.
Sugar R.
Mackinaw R.
Big Vermilion R.
Sangamon R.
MISSISSIPPI RIVER
Embarrass R.
Wabash R.
Little Wabash R.
Saline R.
OHIO RIVER
.....Ill. and Mich. Canal
.....Ill. and Miss. Canal
.....Drainage Canal
. County Seat

LXVII
Distribution
of
Percopsis
guttatus

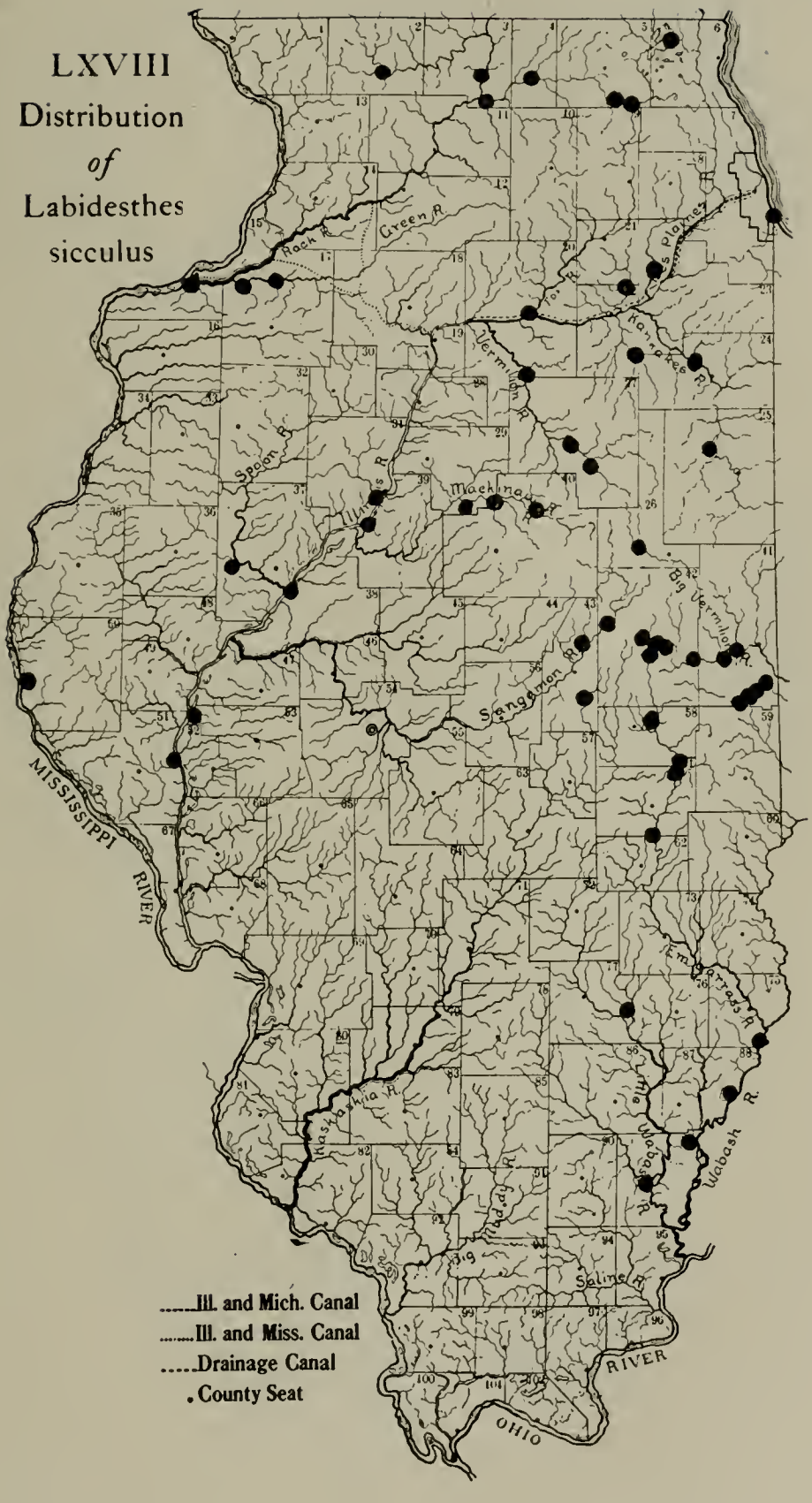
LXVIII

Distribution

of

Labidesthes

sicculus



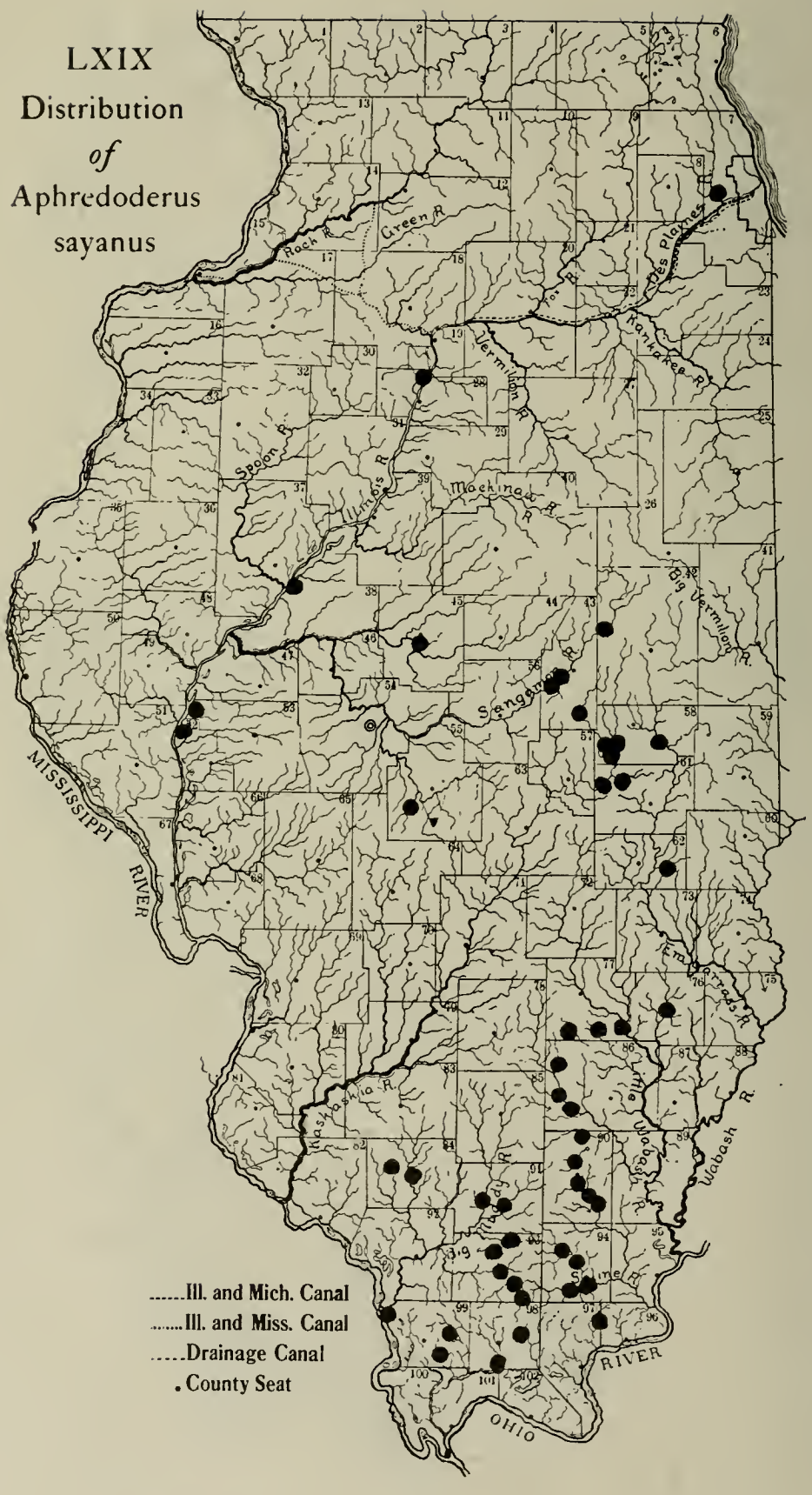
LXIX

Distribution

of

Aphredoderus

sayanus



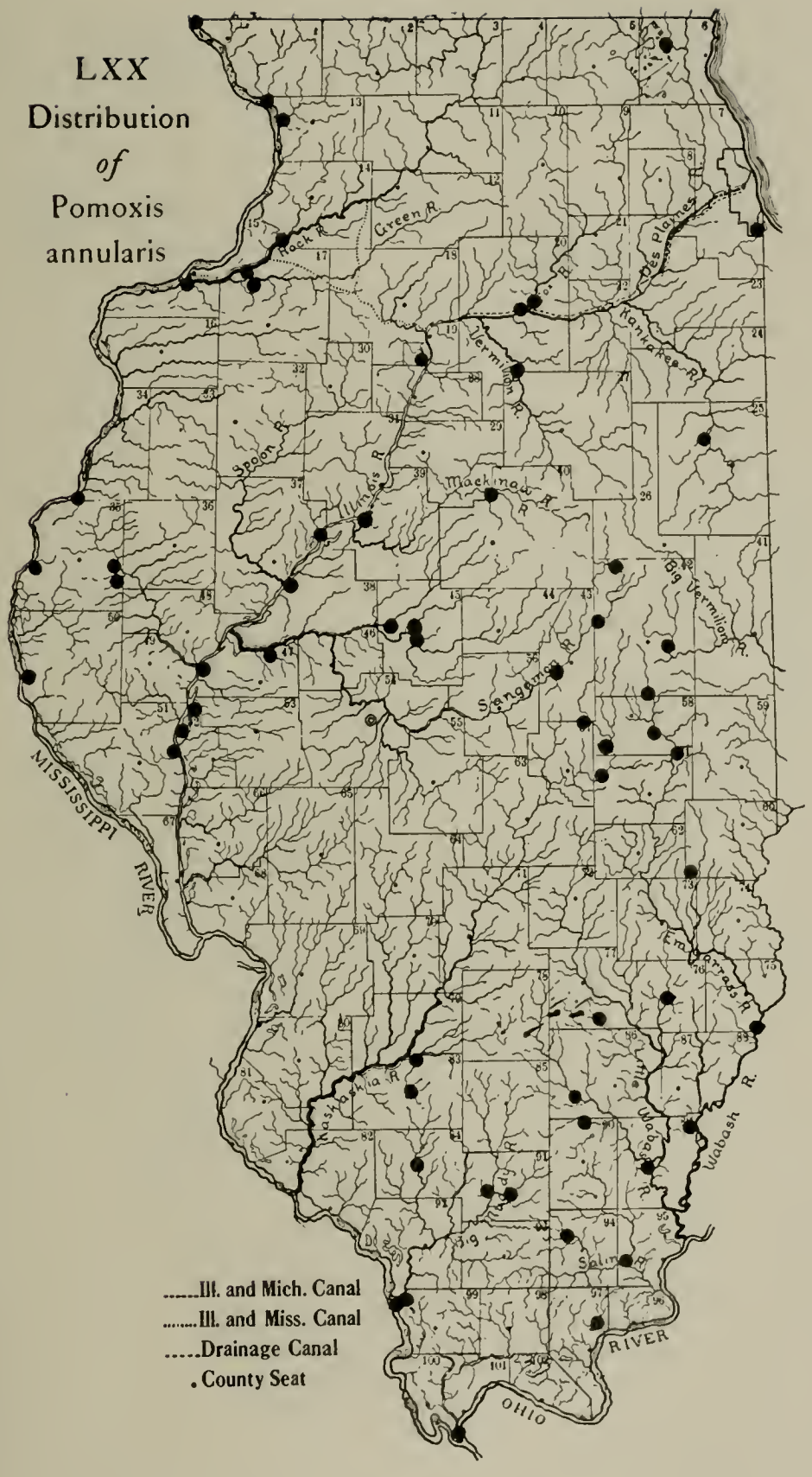
LXX

Distribution

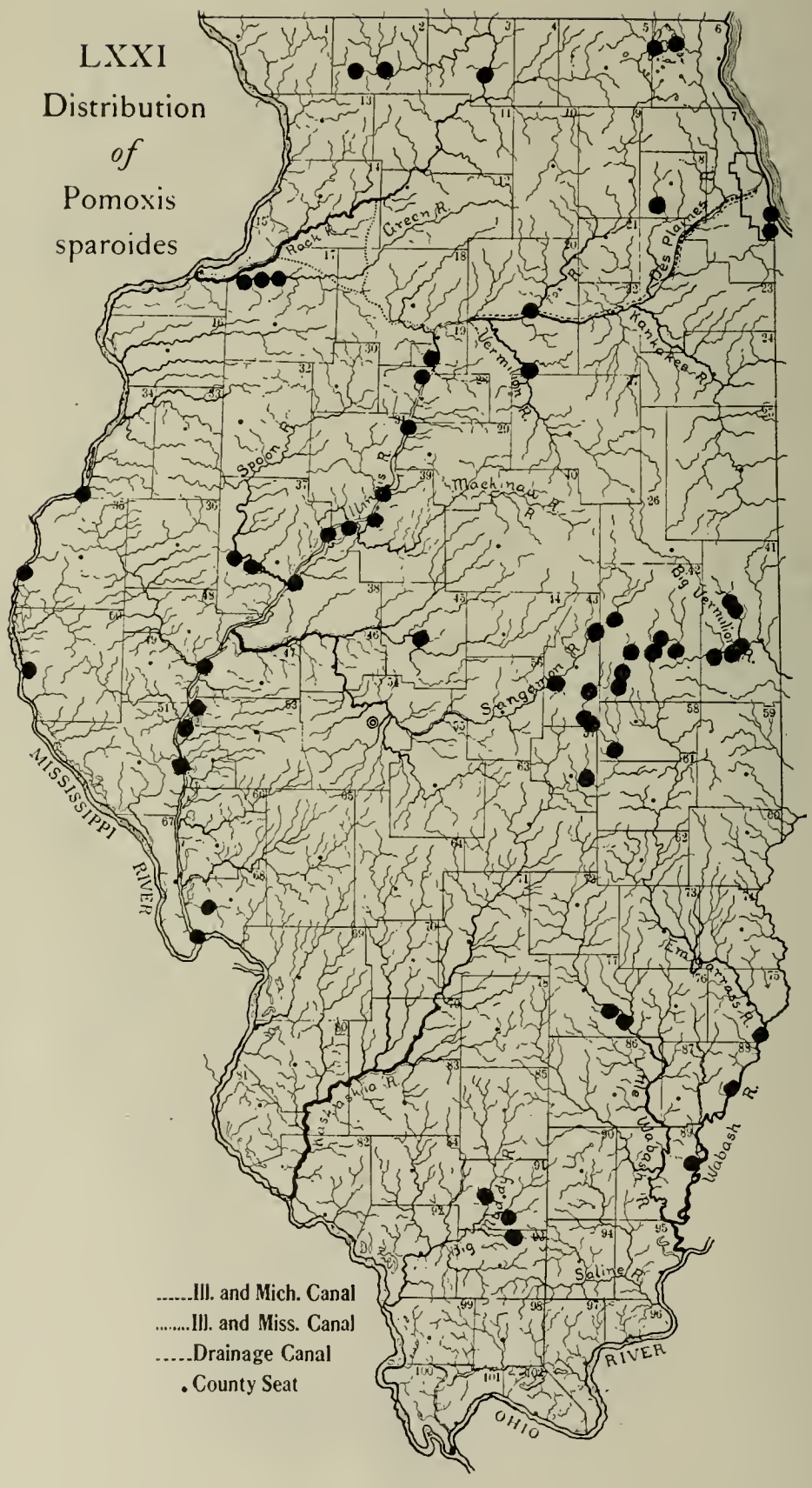
of

Pomoxis

annularis



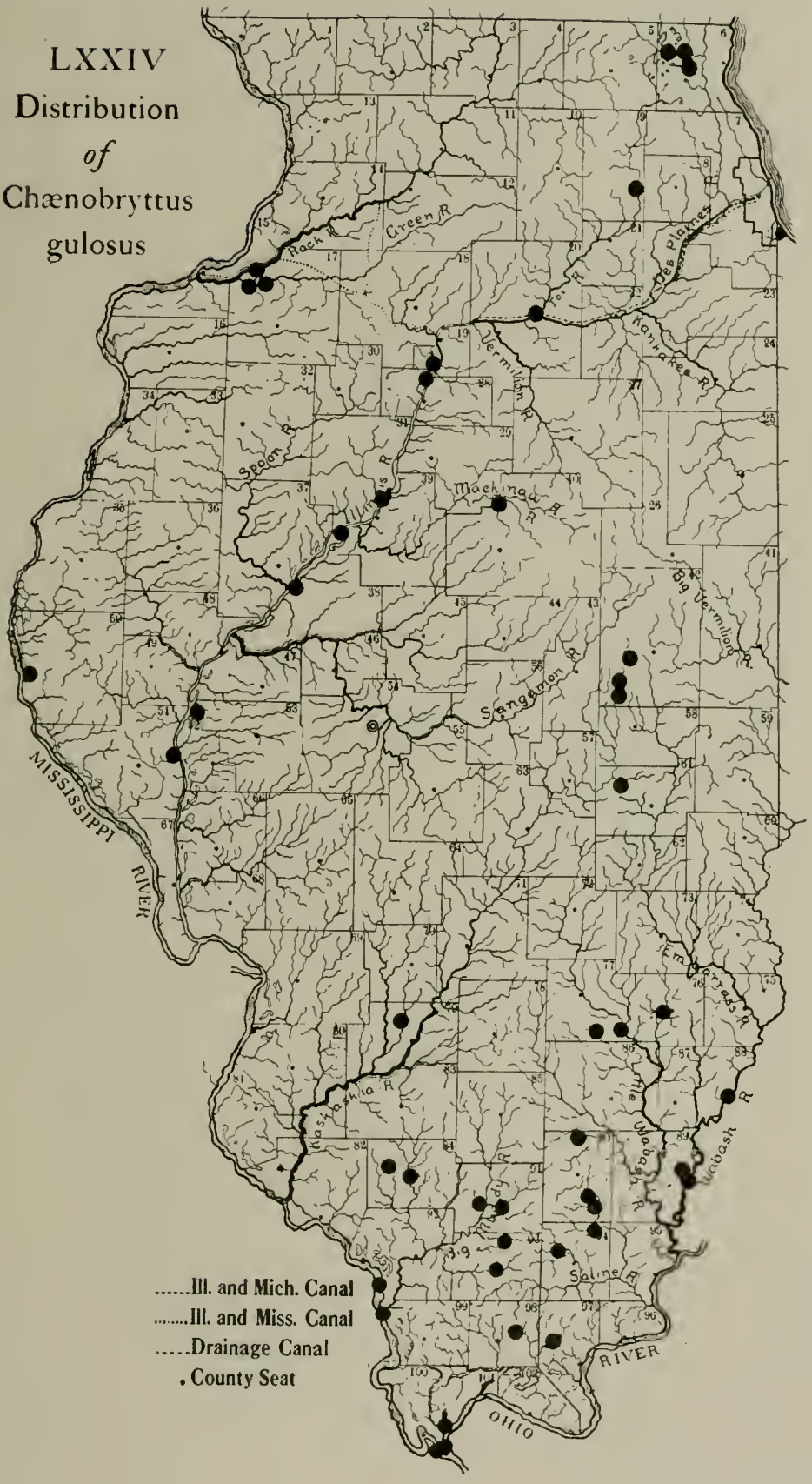
LXXI
Distribution
of
Pomoxis
sparoides



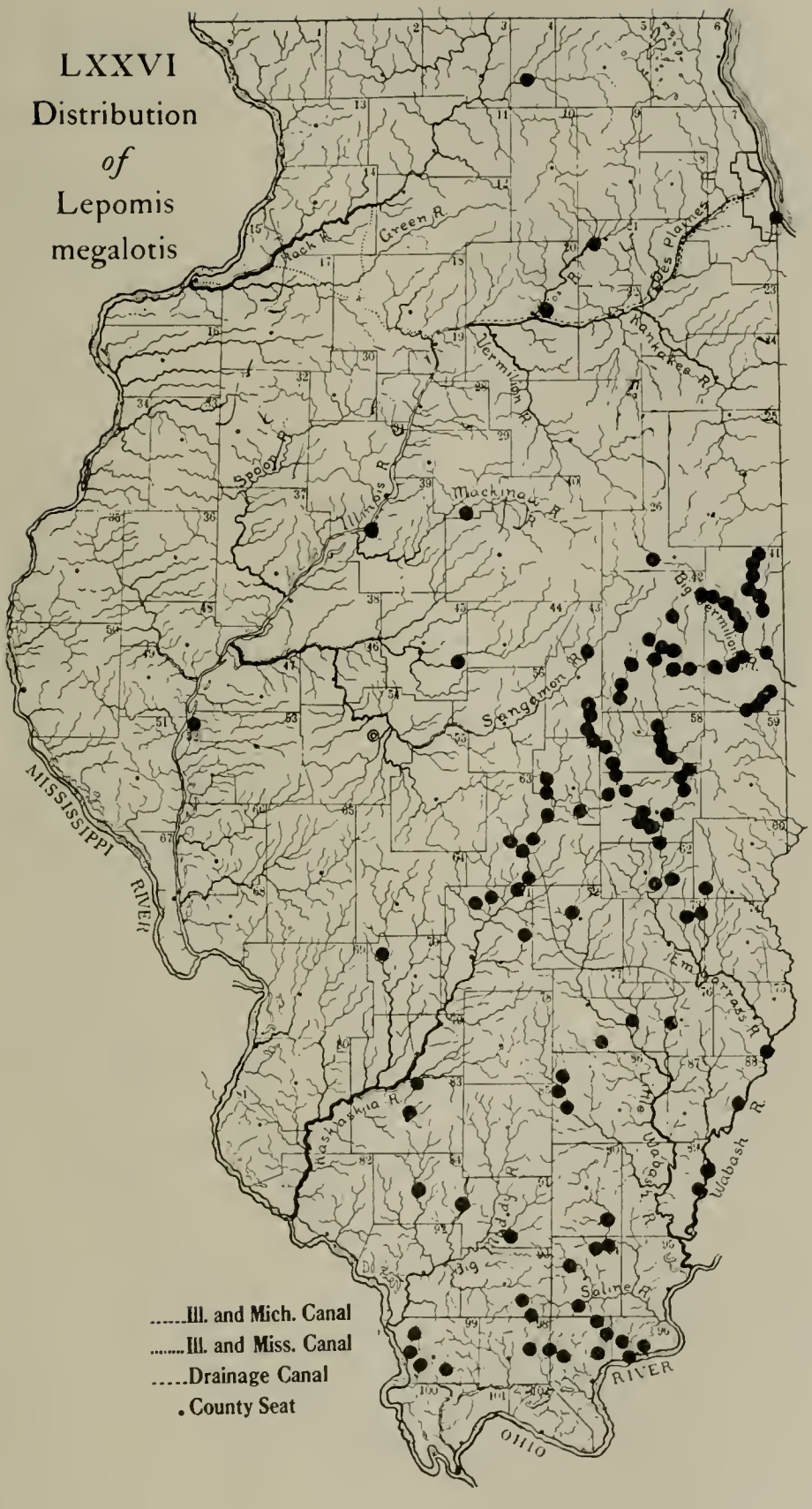
LXXII
Distribution
of
Centrarchus
macropterus

LXXIII
Distribution
of
Ambloplites
rupestris

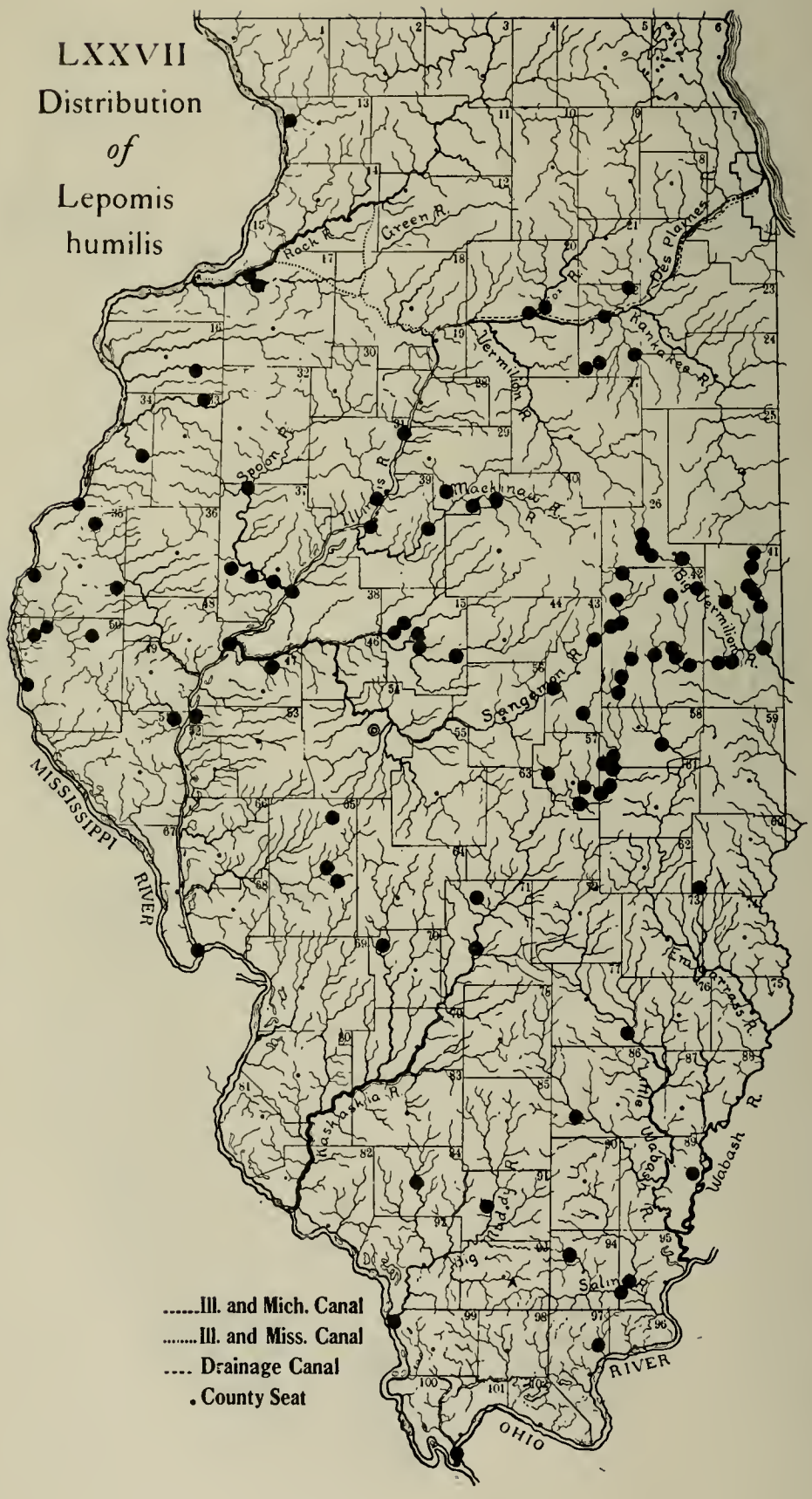
LXXIV
Distribution
of
Chænobryttus
gulosus

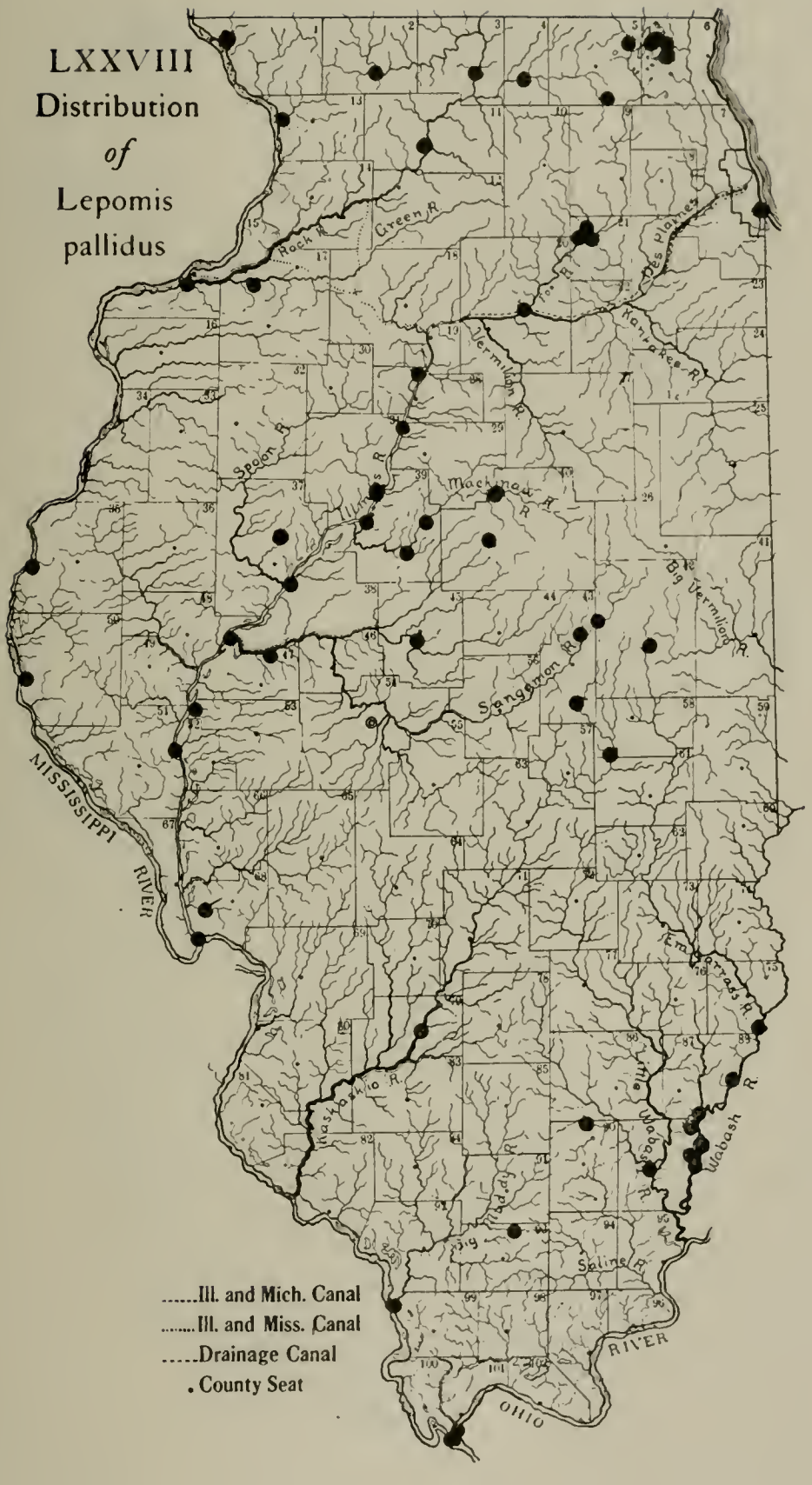


LXXV
Distribution
of
Lepomis
miniatus

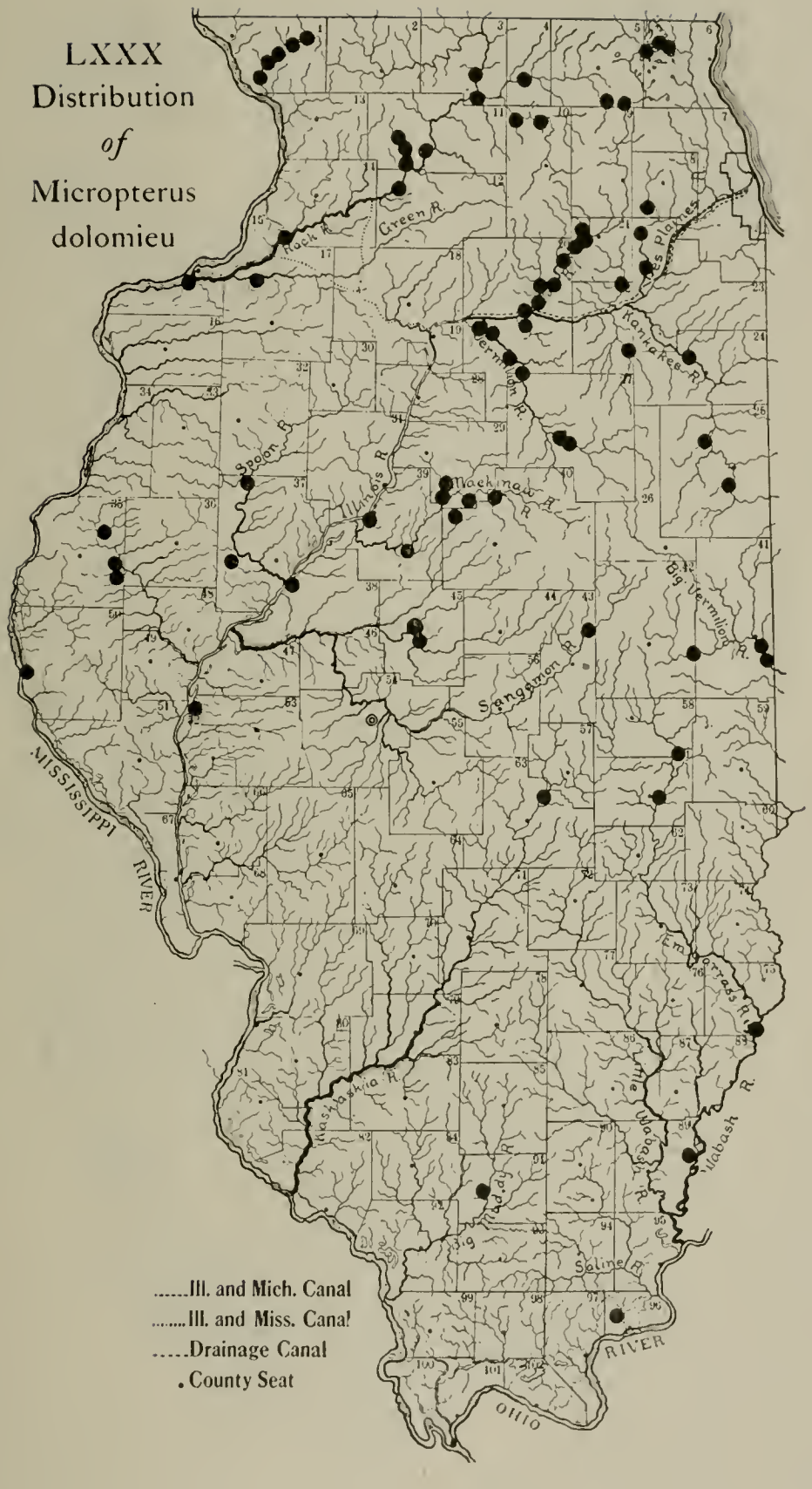

LXXVI
Distribution
of
Lepomis
megalotis
Rock R.
Green R.
Des Plaines R.
Kankakee R.
Vermilion R.
Spoon R.
Illinois R.
Mackinaw R.
Big Vermilion R.
Sangamon R.
MISSISSIPPI RIVER
Embarras R.
Wabash R.
Kaskaskia R.
Big Muddy R.
Saline R.
OHIO RIVER
.....Ill. and Mich. Canal
.....Ill. and Miss. Canal
.....Drainage Canal
. County Seat

LXXVII
Distribution
of
Lepomis
humilis

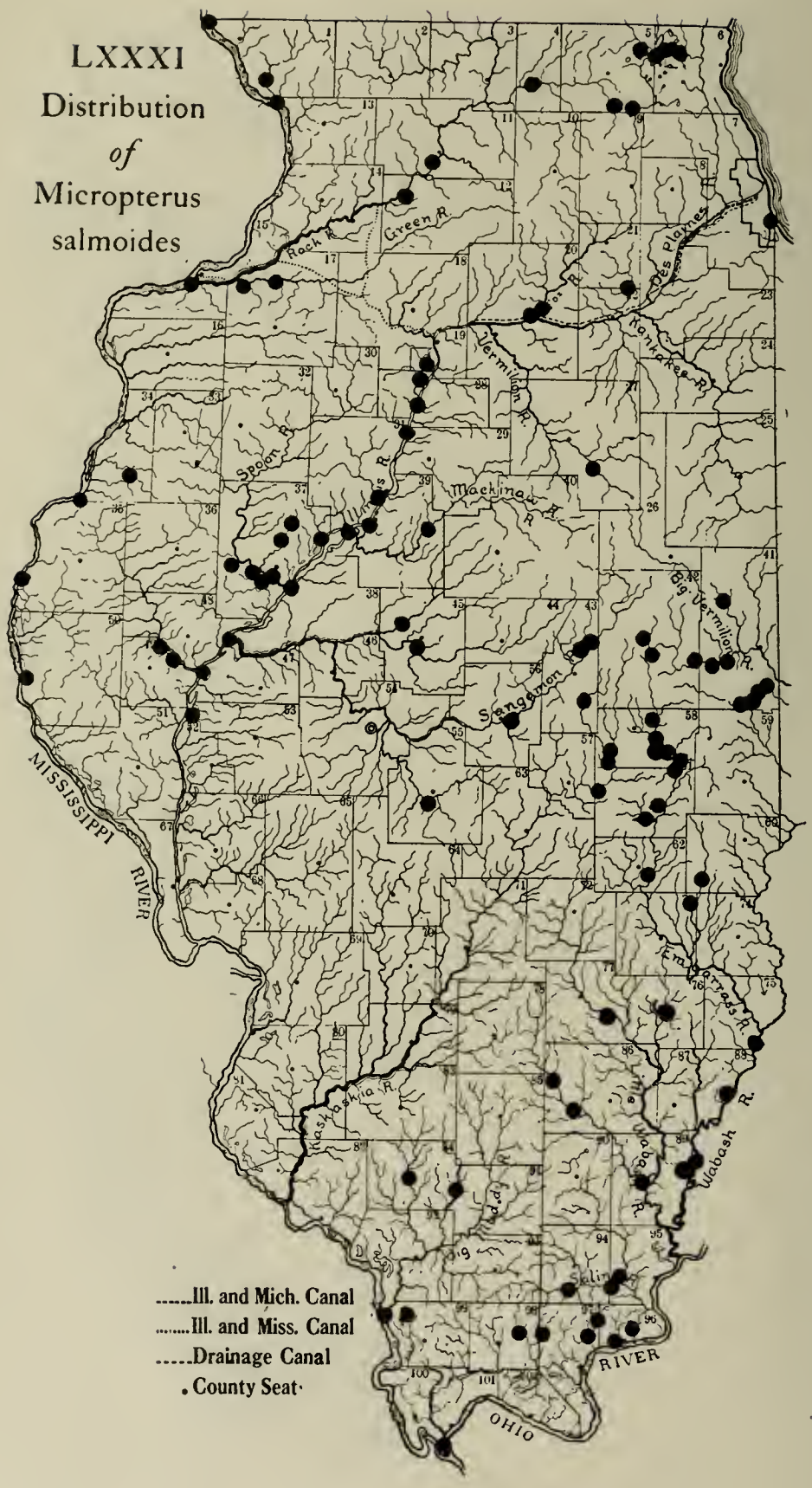



LXXVIII
Distribution
of
Lepomis
pallidus
Rock R.
Green R.
Des plaines R.
Kankakee R.
Vermilion R.
Spoon R.
Illinois R.
Mackinaw R.
Big Vermilion R.
Sangamon R.
MISSISSIPPI
RIVER
Embarras R.
Little Wabash R.
Wabash R.
Kaskaskia R.
Big Muddy R.
Saline R.
OHIO
RIVER
.....Ill. and Mich. Canal
.....Ill. and Miss. Canal
.....Drainage Canal
. County Seat

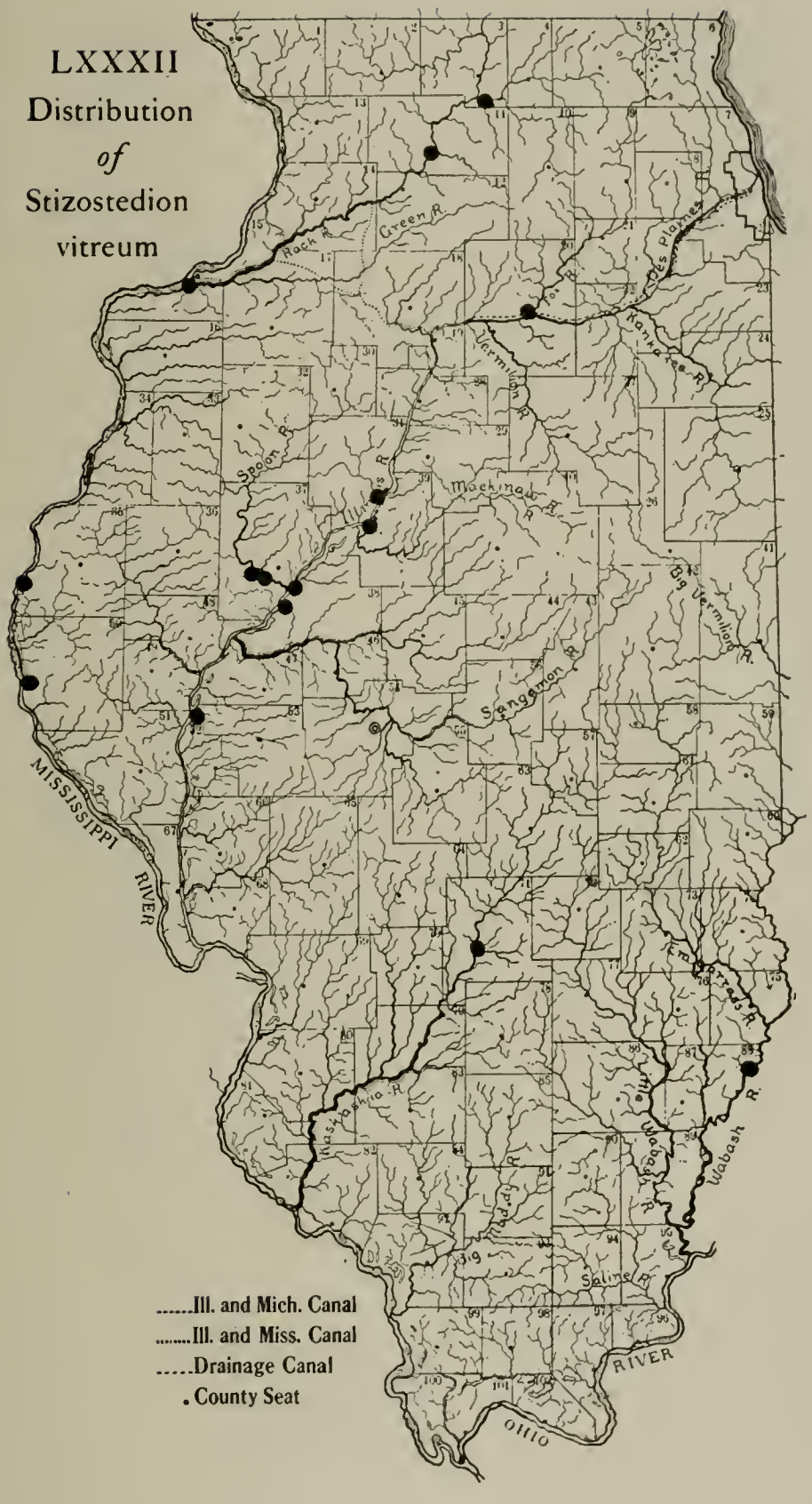

LXXIX.
Distribution
of
Eupomotis
gibbosus
Rock R.
Green R.
Des Plaines R.
Kankakee R.
Vermilion R.
Spoon R.
Illinois R.
Mackinaw R.
Big Vermilion R.
Sangamon R.
MISSISSIPPI
RIVER
Embarras R.
Little Wabash R.
Wabash R.
Saline R.
RIVER
OHIO
.....Ill. and Mich. Canal
.....Ill. and Miss. Canal
-----Drainage Canal
. County Seat


LXXX
Distribution
of
Micropterus
dolomieu
Rock R.
Green R.
Des Plaines R.
Kankakee R.
Vermilion R.
Spoon R.
Illinois R.
Mackinaw R.
Big Vermilion R.
Sangamon R.
MISSISSIPPI RIVER
Embarras R.
Little Wabash R.
Wabash R.
Saline R.
OHIO RIVER
.....Ill. and Mich. Canal
.....Ill. and Miss. Canal
.....Drainage Canal
. County Seat

LXXXI
Distribution
of
Micropterus
salmoides

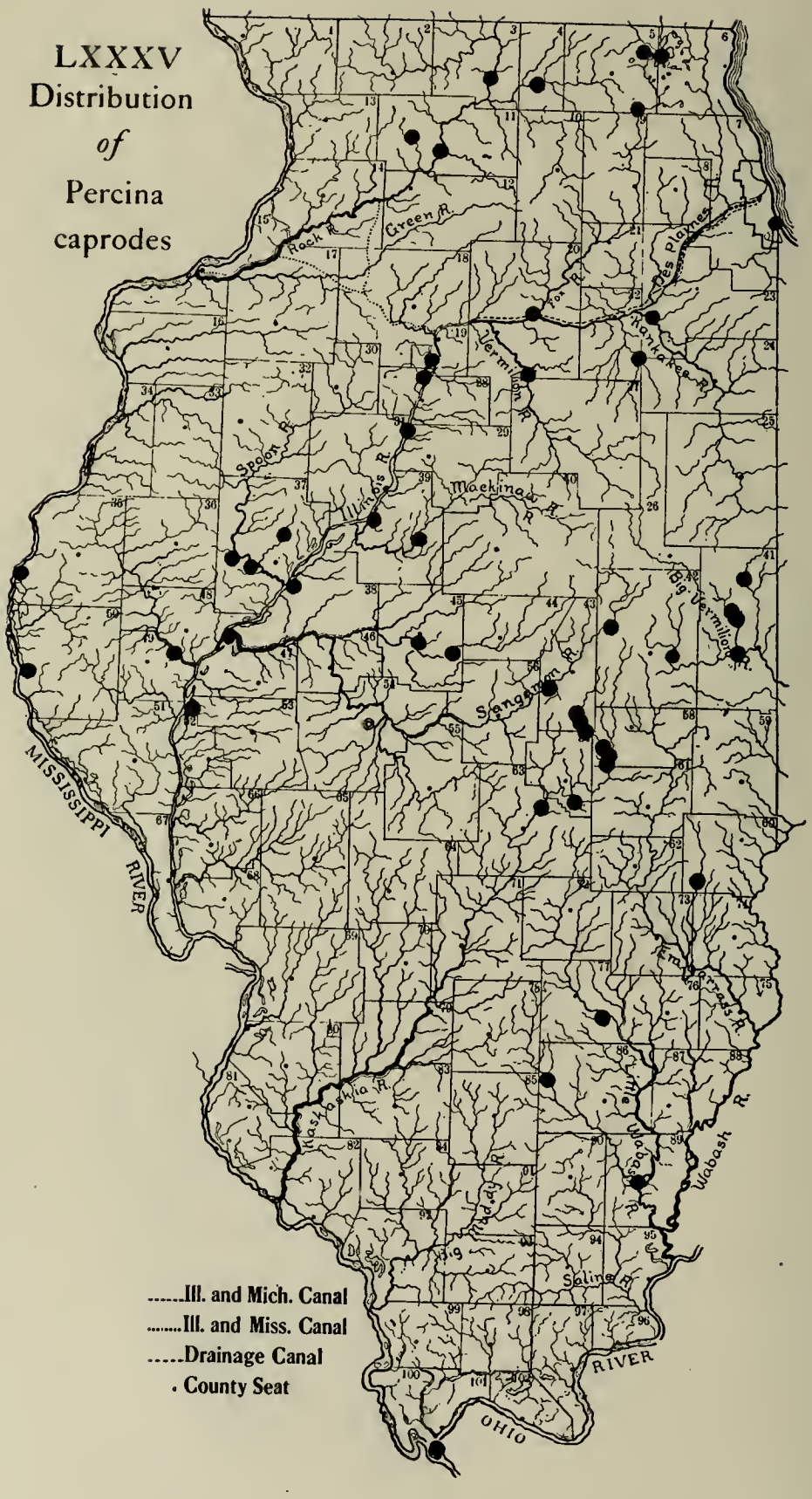


LXXXII
Distribution
of
Stizostedion
vitreum

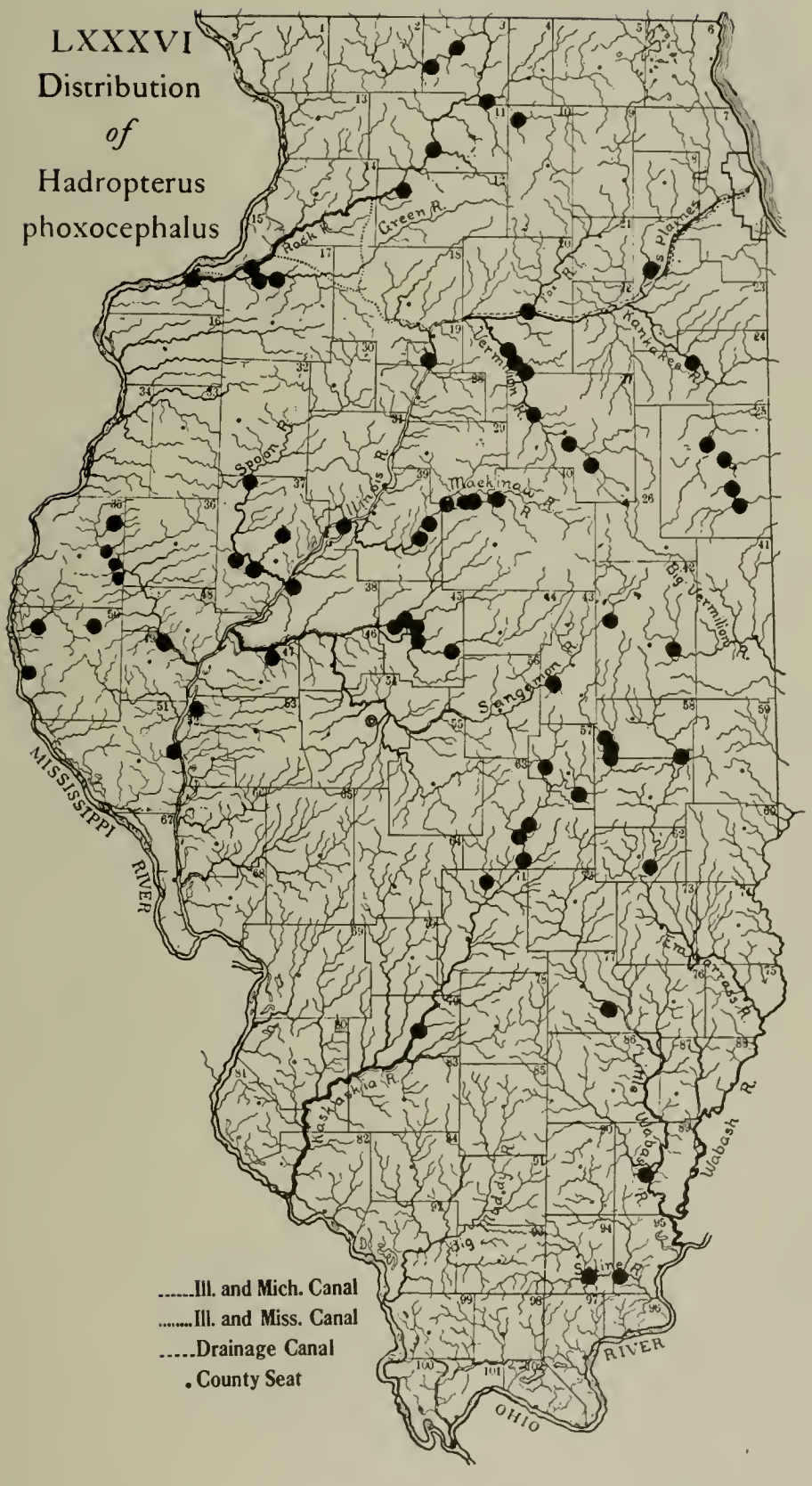


LXXXIII
Distribution
of
Stizostedion
canadense
griseum

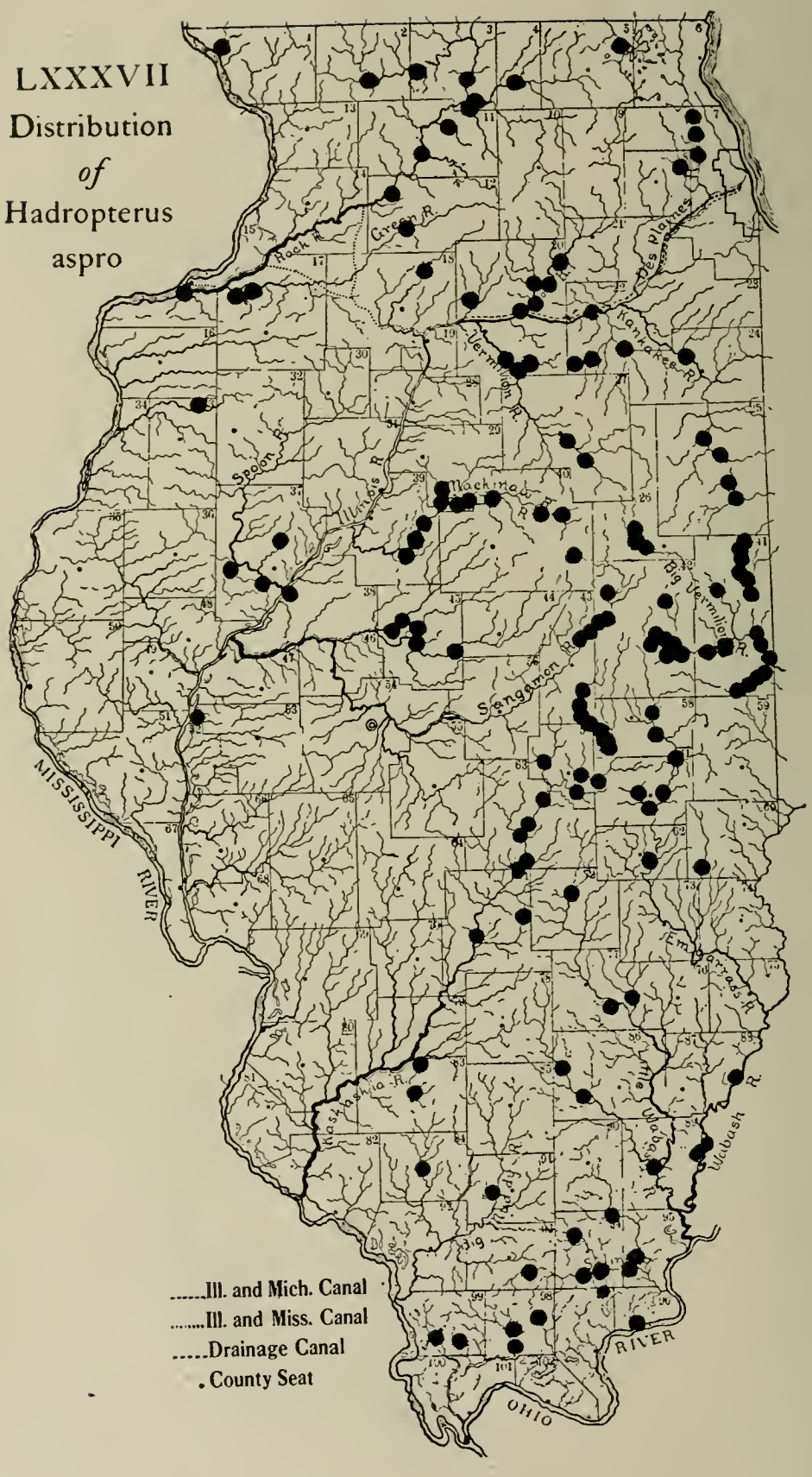

LXXXIV
Distribution
of
Perca
flavescens
Rock R.
Green R.
Des Plaines R.
Kankakee R.
Vermilion R.
Illinois R.
Mackinaw R.
Spoon R.
Big Vermilion R.
Sangamon R.
MISSISSIPPI RIVER
Embarras R.
Little Wabash R.
Wabash R.
Kaskaskia R.
Big Muddy R.
Saline R.
OHIO RIVER
.....Ill. and Mich. Canal
.....Ill. and Miss. Canal
.....Drainage Canal
. County Seat


LXXXV
Distribution
of
Percina
caprodes
Rock R.
Green R.
Des Plaines R.
Kankakee R.
Vermilion R.
Spoon R.
Illinois R.
Mackinaw R.
Big Vermilion R.
Sangamon R.
MISSISSIPPI RIVER
Embarras R.
Little Wabash R.
Wabash R.
Kaskaskia R.
Big Muddy R.
Saline R.
RIVER
OHIO
.....Ill. and Mich. Canal
.....Ill. and Miss. Canal
.....Drainage Canal
. County Seat

LXXXVI
Distribution
of
Hadropterus
phoxocephalus

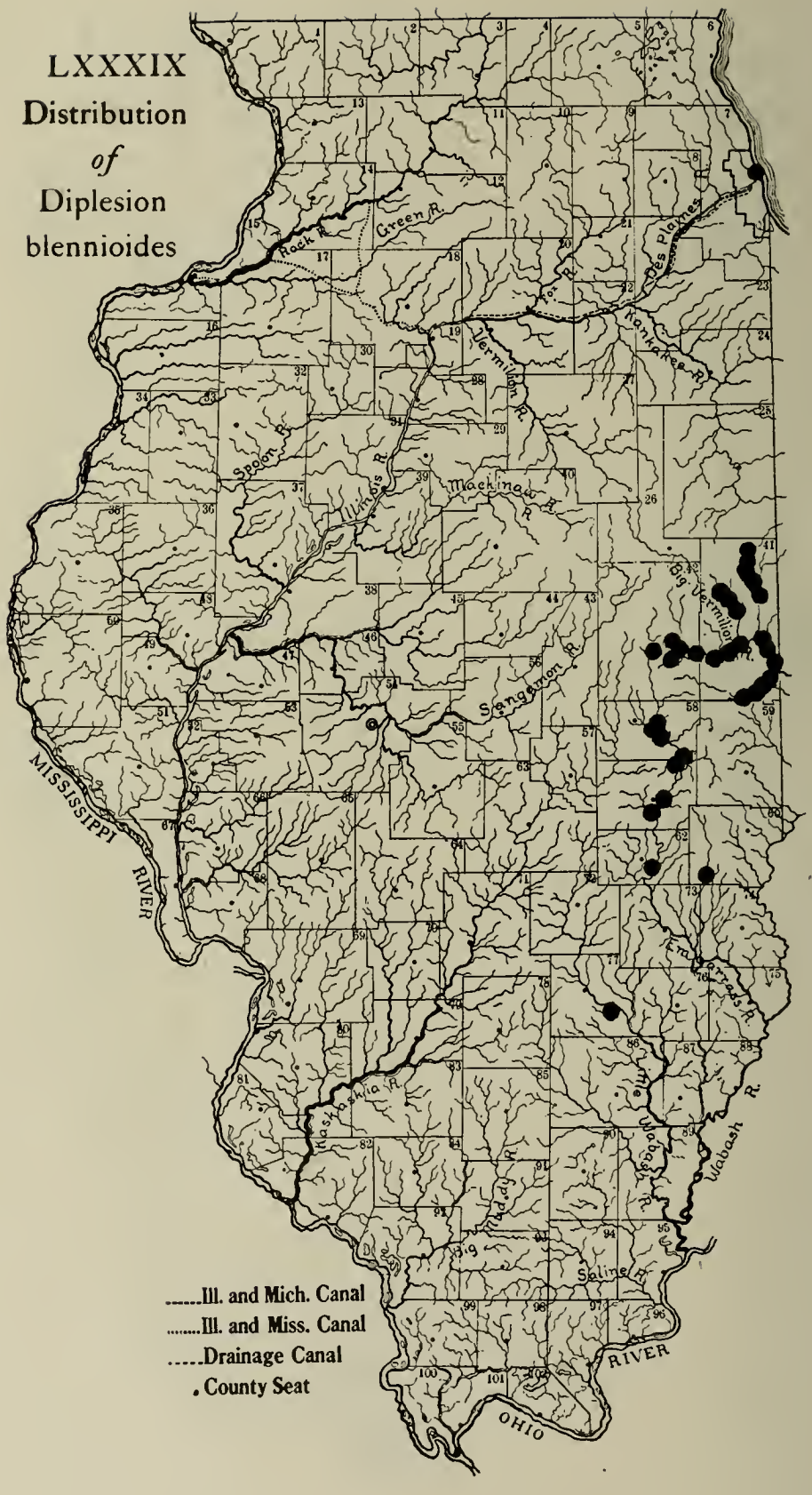


LXXXVII
Distribution
of
Hadropterus
aspro

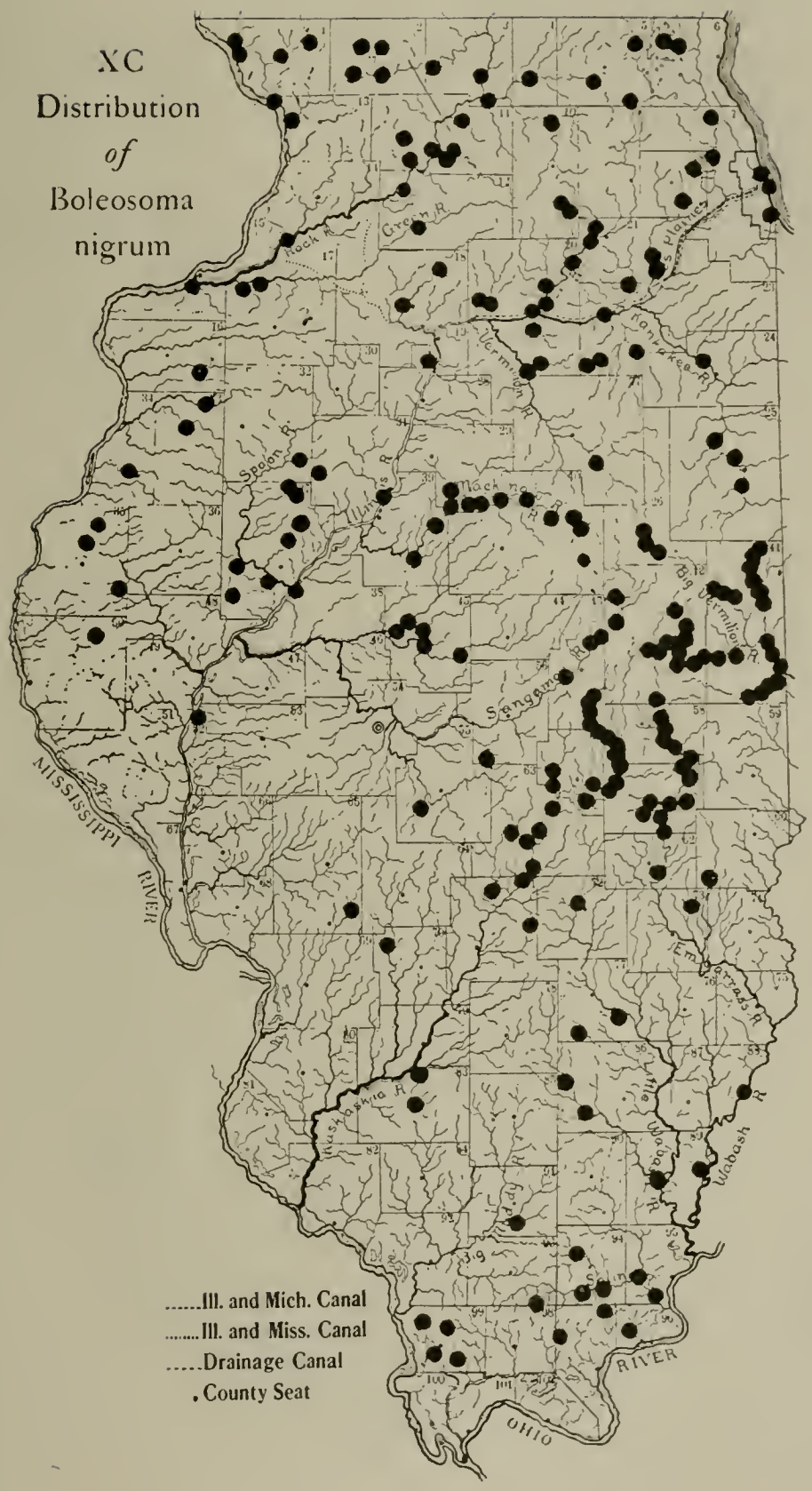


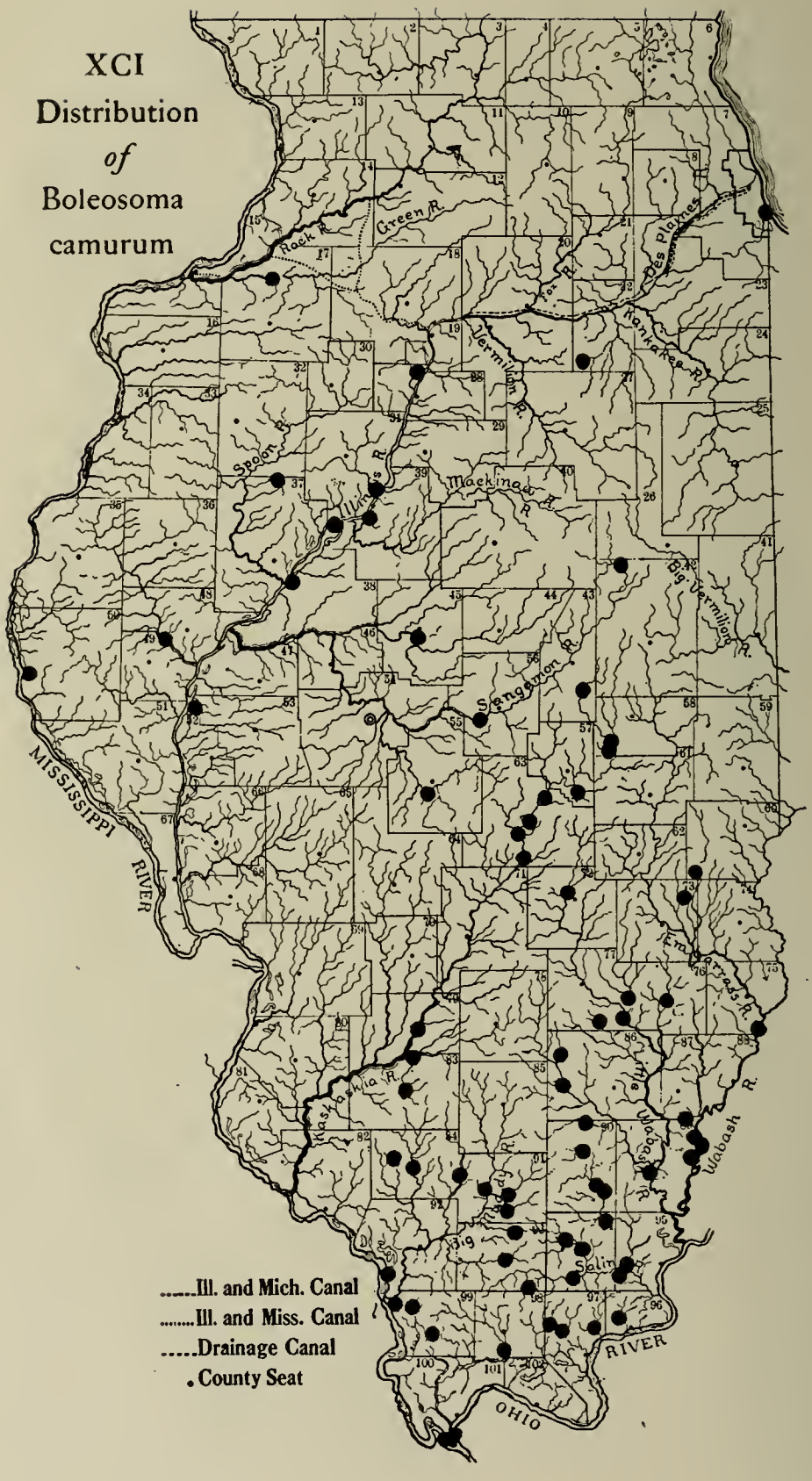

LXXXVIII
Distribution
of
Cottogaster
shumardi
Rock R.
Green R.
Des plaines R.
Kankakee R.
Vermilion R.
Spoon R.
Illinois R.
Mackinaw R.
Big Vermilion R.
Sangamon R.
MISSISSIPPI
RIVER
Embarras R.
Little Wabash R.
Wabash R.
Kaskaskia R.
Big Muddy R.
Saline R.
OHIO
RIVER
.....Ill. and Mich. Canal
.....Ill. and Miss. Canal
.....Drainage Canal
. County Seat

LXXXIX
Distribution
of
Diplesion
blennioides

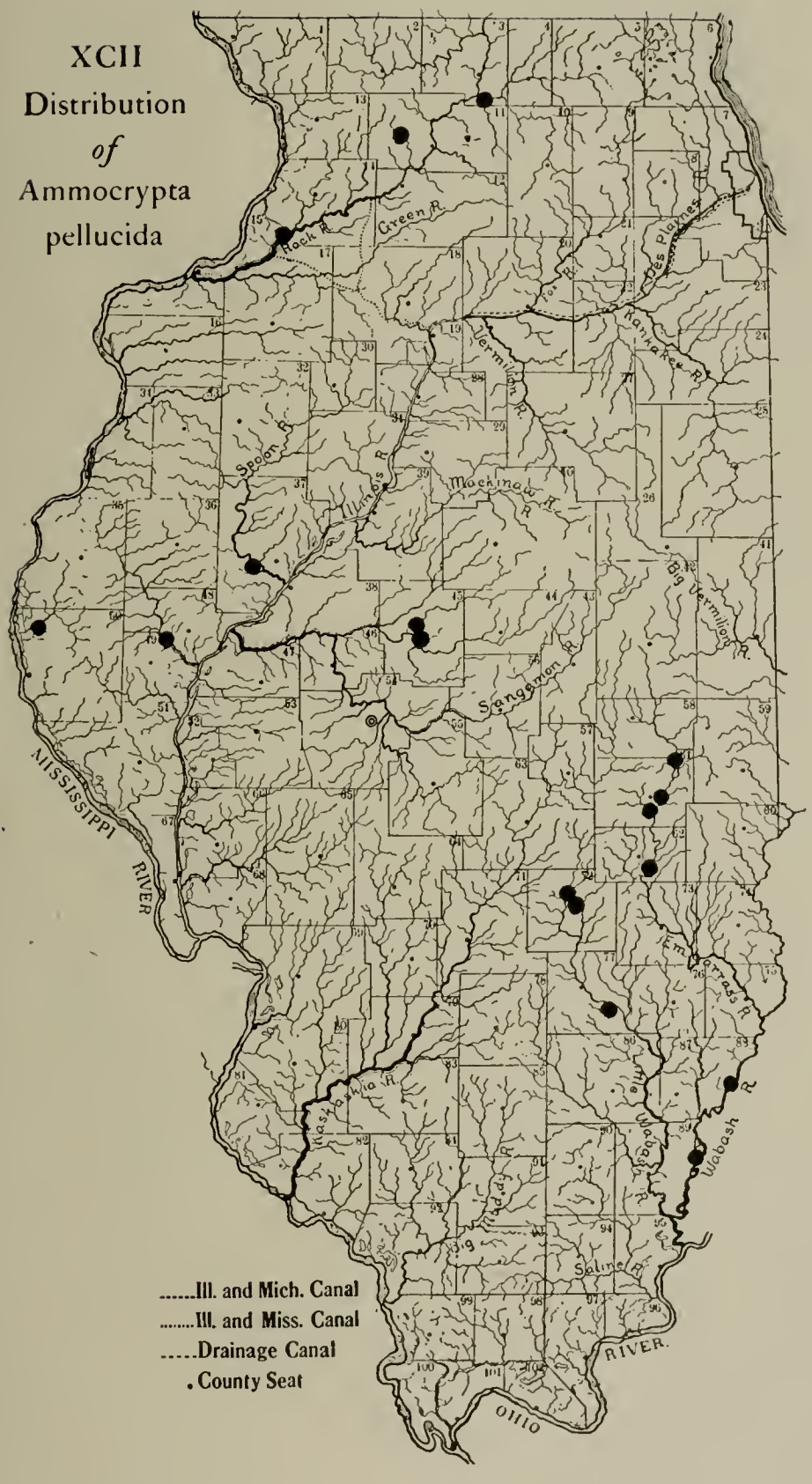


XC
Distribution
of
Boleosoma
nigrum



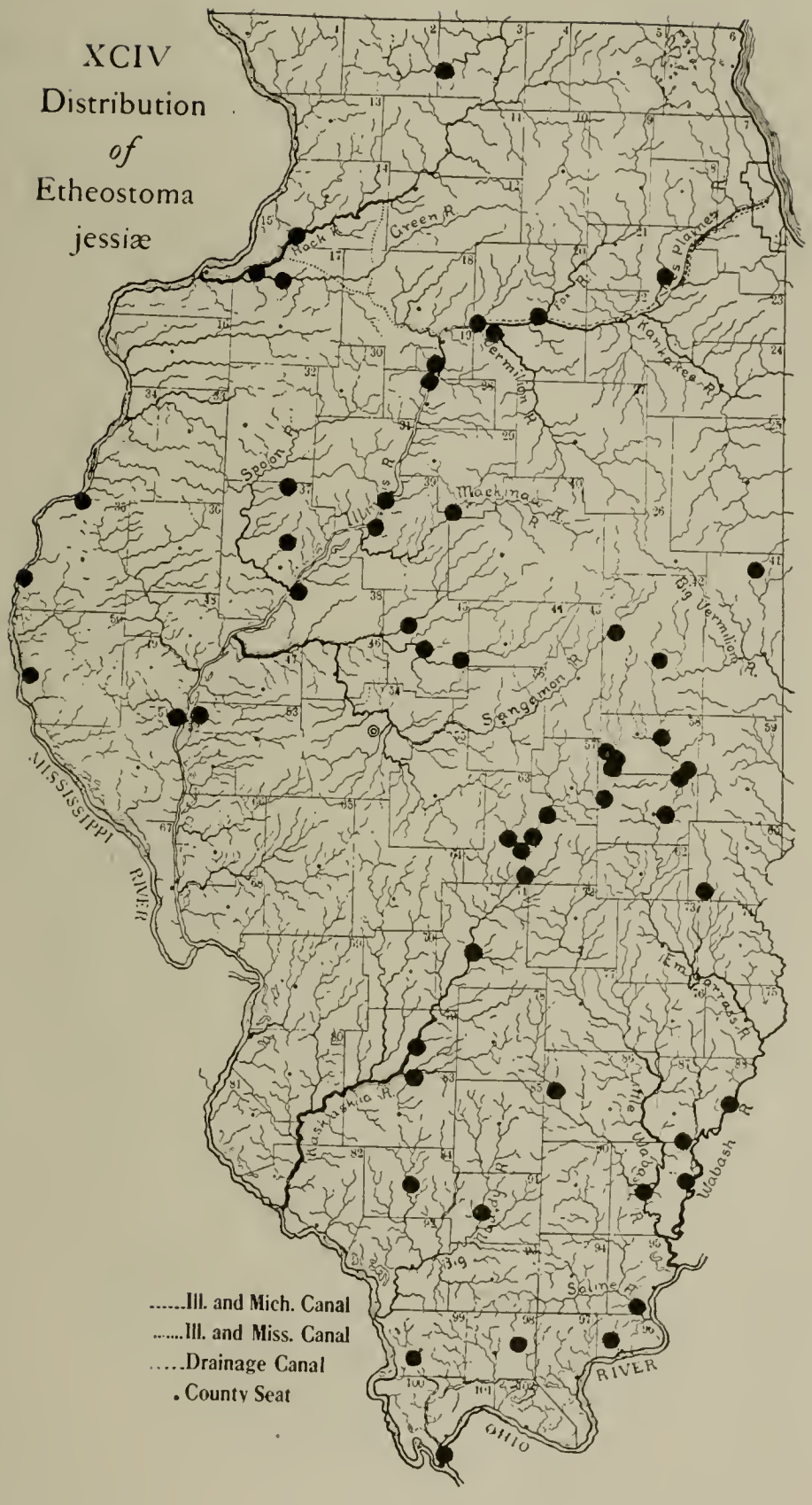

XCI
Distribution
of
Boleosoma
camurum
Rock R.
Green R.
Des plaines R.
Kankakee R.
Vermilion R.
Spoon R.
Illinois R.
Mackinaw R.
Big Vermilion R.
Sangamon R.
MISSISSIPPI RIVER
Kaskaskia R.
Embarras R.
Wabash R.
Saline
RIVER
OHIO
.....Ill. and Mich. Canal
.....Ill. and Miss. Canal
.....Drainage Canal
. County Seat

XCII
Distribution
of
Ammocrypta
pellucida

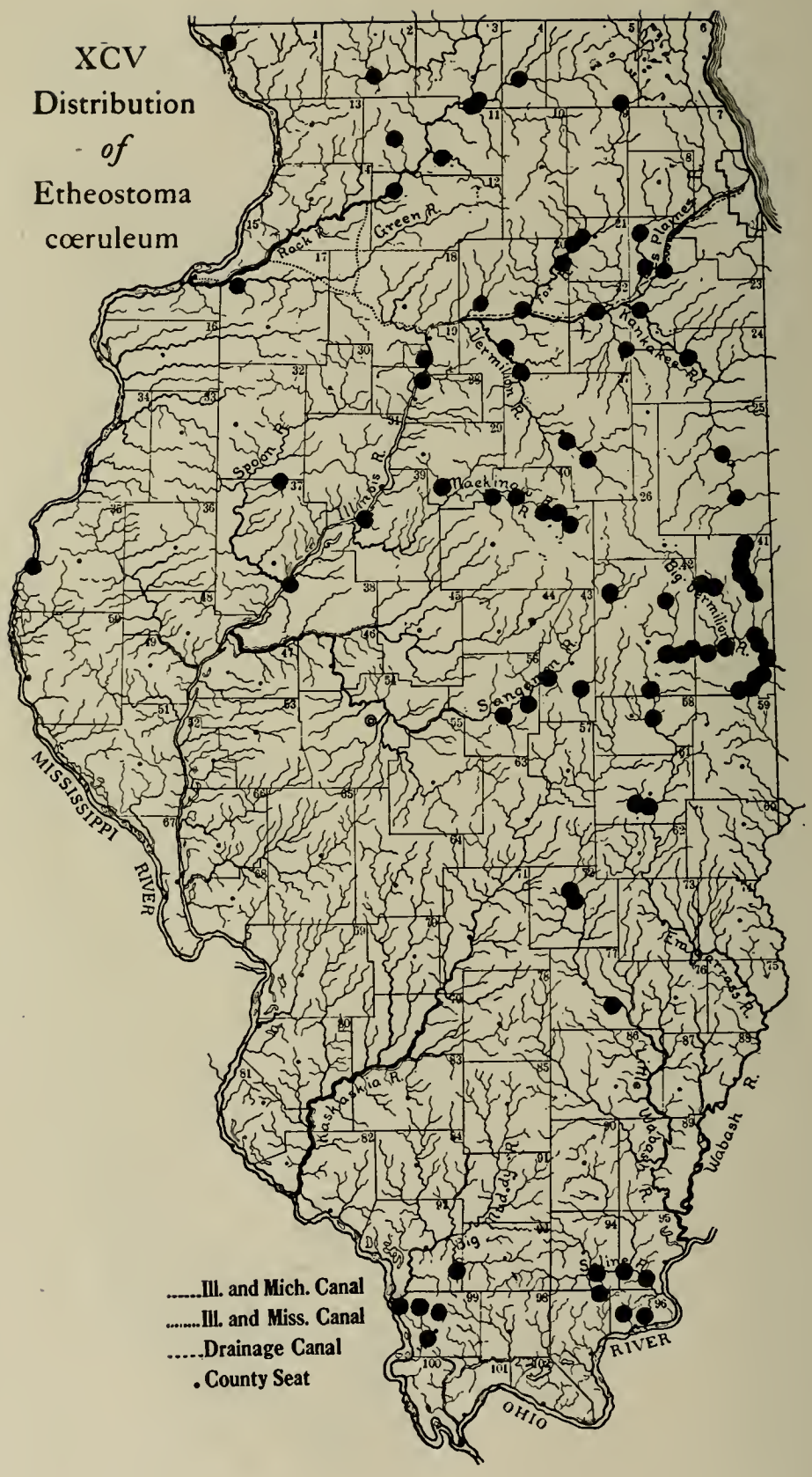


XCIII
Distribution
of
Etheostoma
zonale

XCIV
Distribution
of
Etheostoma
jessiæ

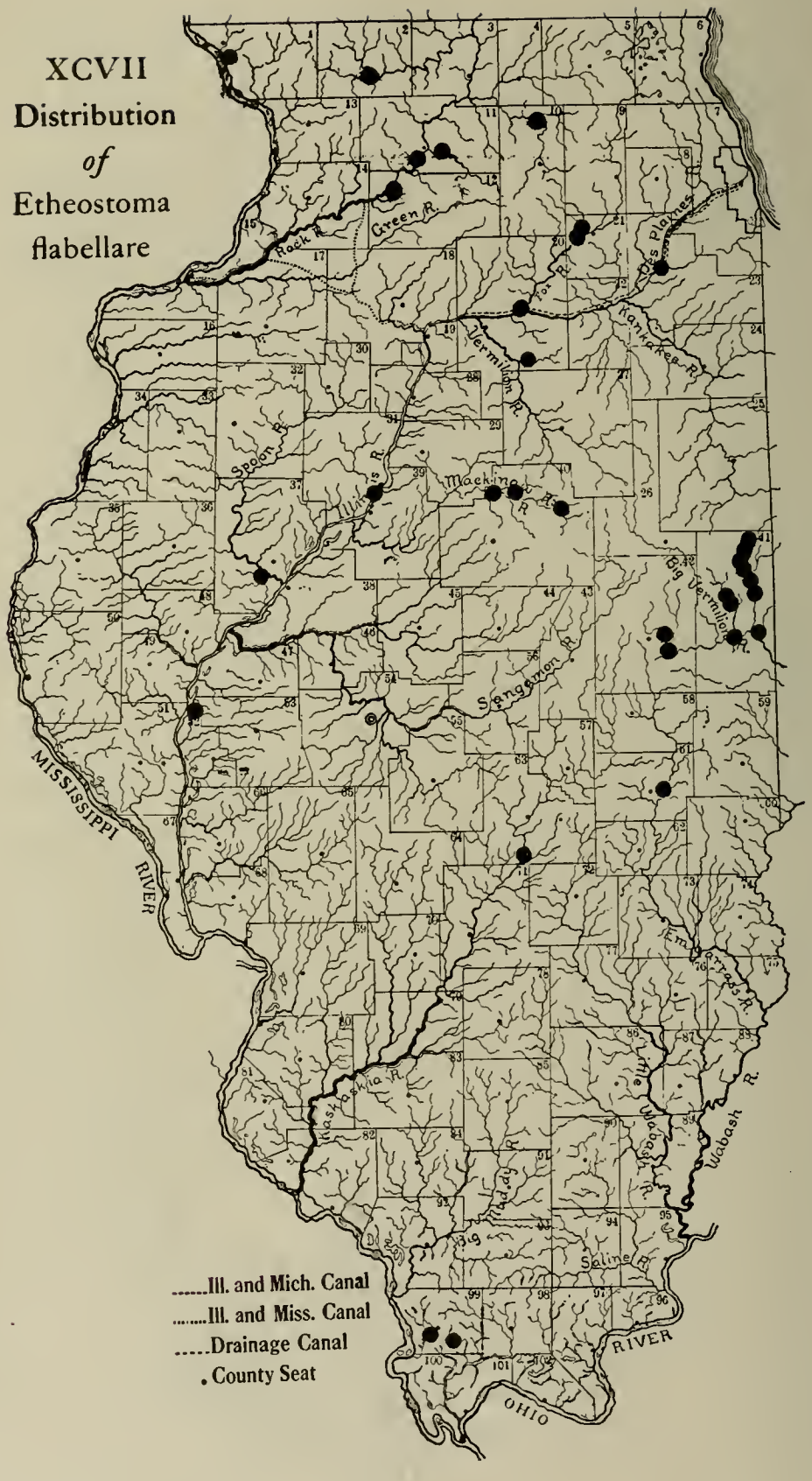


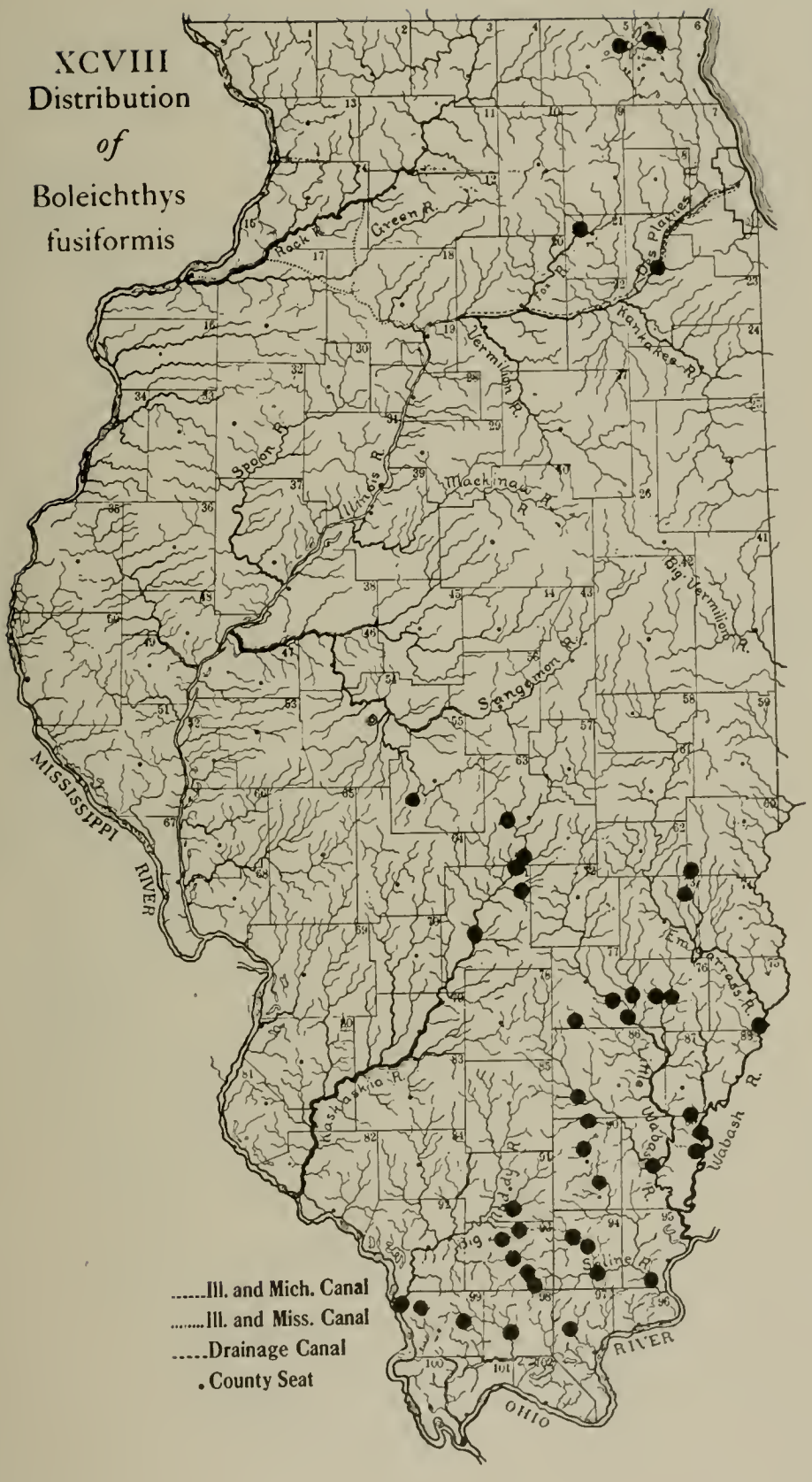
XCV
Distribution
of
Etheostoma
cœruleum




XCVI
Distribution
of
Etheostoma
squamiceps
Rock R.
Green R.
Des plaines R.
Kankakee R.
Vermilion R.
Spoon R.
Illinois R.
Mackinaw R.
Big Vermilion R.
Sangamon R.
MISSISSIPPI RIVER
Embarras R.
Little Wabash R.
Wabash R.
Kaskaskia R.
Big Muddy R.
Saline R.
OHIO RIVER
.....Ill. and Mich. Canal
.....Ill. and Miss. Canal
.....Drainage Canal
. County Seat

XCVII
Distribution
of
Etheostoma
flabellare




XCVIII
Distribution
of
Boleichthys
fusiformis
Rock R.
Green R.
Des Plaines R.
Fox R.
Kankakee R.
Vermilion R.
Spoon R.
Illinois R.
Mackinaw R.
Big Vermilion R.
Sangamon R.
MISSISSIPPI RIVER
Embarras R.
Little Wabash R.
Wabash R.
Kaskaskia R.
Big Muddy R.
Saline R.
RIVER
OHIO
.....Ill. and Mich. Canal
.....Ill. and Miss. Canal
.....Drainage Canal
. County Seat


XCIX
Distribution
of
Microperca
punctulata
Rock R.
Green R.
Des Plaines R.
Kankakee R.
Vermilion R.
Spoon R.
Illinois R.
Mackinaw R.
Big Vermilion R.
Sangamon R.
MISSISSIPPI RIVER
Embarras R.
Little Wabash R.
Wabash R.
Kaskaskia R.
Big Muddy R.
Saline R.
RIVER
OHIO
.....Ill. and Mich. Canal
.....Ill. and Miss. Canal
.....Drainage Canal
. County Seat


C
Distribution
of
Roccus
chrysops
Rock R.
Green R.
Des plaines R.
Kankakee R.
Vermilion R.
Spoon R.
Illinois R.
Mackinaw R.
Big Vermilion R.
Sangamon R.
MISSISSIPPI RIVER
Kaskaskia R.
Embarras R.
Wabash R.
Big Muddy R.
Saline R.
OHIO RIVER
.....Ill. and Mich. Canal
.....Ill. and Miss. Canal
.....Drainage Canal
. County Seat


CI
Distribution
of
Morone
interrupta
Rock R.
Green R.
Des Plaines R.
Kankakee R.
Vermilion R.
Spoon R.
Illinois R.
Mackinaw R.
Big Vermilion R.
Sangamon R.
MISSISSIPPI RIVER
Embarras R.
Little Wabash R.
Wabash R.
Saline R.
OHIO RIVER
.....Ill. and Mich. Canal
.....Ill. and Miss. Canal
.....Drainage Canal
. County Seat

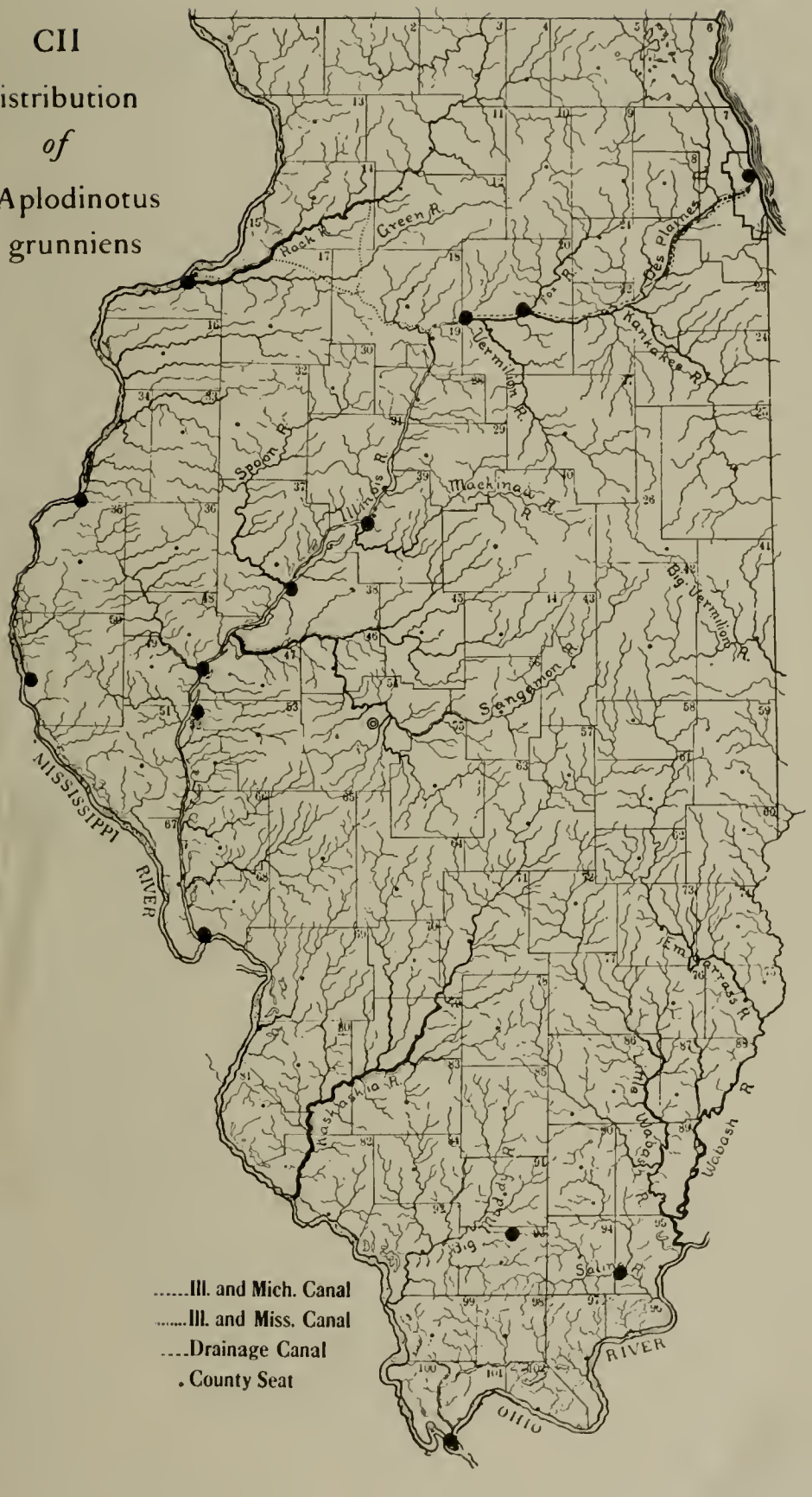
CII

Distribution

of

Aplodinotus

grunniens



CIII

Northern species (●)
and
Southern species (▲)
in Illinois